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NEW TRENDS IN TECHNOLOGY, AND THEIR APPLICATIONS: GEODESY

Mapping applications of the global positioning systems on airborne platforms

Paper submitted by the United States of America**

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INTRODUCTION

Numerous investigators have reported their experience using the GPS to support aerotriangulation through the determination of camera station positions at the time of exposure. The U.S. Geological Survey (USGS) began investigating this technnique to reduce the cost of acquiring ground-surveyed control for planimetric revision and digital orthophoto (DOQ) production. Images to support revision and DOQ production programs will largely be at 1:40,000-scale and acquired through the National Aerial Photography Program (NAPP). Current specifications require third-order, photoidentifiable, horizontal control points to be located at a spacing of 7.5 minutes around the perimeter of a project and at 15 minute spacing on the interior of a project to control aerotriangulation using NAPP images. The cost of establishing these points is estimated to be between $200 and $1,000 per point, depending on factors such as terrain type, number of points to be established in a given area, and spacing of existing, monumented control. For airborne GPS to provide a cost-effective alternative to conventional aerotriangulation, the acquisition and processing of GPS positions for the camera station must be less than the cost of acquisition of ground control over the imaged area. Thus, although the theory behind the use of airborne GPS seems well proven, the application of this technology to a large mapping program is dependent on cost and flexibility, as well as on technology.

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PREVIOUS INVESTIGATIONS

The theoretical potential for the use of GPS-derived camera positions to control block adjustments was presented by Lucas (1987). Through simulation studies, Lucas showed that if GPS observations were available with a standard error of 10 centimeters in each component (assuming an offset vector between the GPS antenna and camera known to 10 centimeters), then a block adjustment could be performed with results similar to an adjustment achieved using a conventional ground control configuration. Horizontal errors in the block containing GPS observations of the exposure station were only significantly larger than the ground-controlled adjustment at the corners of the block where ground point positions were tightly constrained. Vertical errors were consistently smaller for the GPS block, except in the corners of the block. Since Lucas' theoretical presentation of the potential for the use of GPS in photogrammetry to significantly reduce the amount of ground control necessary for aerotriangulation, many practical experiments have been performed to verify the concept.

The work of the National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA) has been prominent among projects reported in the literature. Lewis Lapine's work at Ohio State (1991) provided a thorough examination of a system calibration made possible by the incorporation of GPS observations of camera station positions to decorrelate interior and exterior orientation elements during in-flight calibration. Burgess and White (1992) reported the results of a joint project between the U.S. Army Topographic Engineering Center, NOS, the Seattle District, and Walker and Associates. The report of this project, conducted in 1990, provides a practical record of a large-scale GPS and photogrammetry mission. The problems encountered in this project, including those caused by frequent vendor software changes and numerous cycle slips, attest to the technical and logistical obstacles remaining to be overcome before the use of GPS-derived camera exposure station positions in photogrammetry may be considered routine.

Schuckman and others (1992) reported a good comparison between aerotriangulation results computed using code-phase vs. carrier-phase observations to determine camera exposure station positions for medium-scale (1:40,000) photography. The practical advantages of using code-phase observables in pseudorange solutions are clear in that initialization before takeoff and maintenance of continuous lock are not required. Ackermann and Schade (1993) also addressed the logistical problems associated with airborne GPS by introducing linear drift parameters in the block adjustment to account for unmodeled, systematic GPS errors present when only C/A code pseudoranges are used to estimate exposure station positions. The need for an initial integer ambiguity resolution is eliminated. However, either substantial sidelap (60 percent), cross-strips, or lines of vertical control along the ends of the flight lines are recommended to strengthen the block adjustment.

The movement of airborne GPS away from research and toward an operational environment is clear from the trends in the literature. The USGS intends to take advantage of this trend by introducing airborne GPS into limited production in 1994. The lessons learned in research projects completed in 1991 and 1992 were invaluable in preparing the technical specifications requiring delivery of airborne GPS data with photographs acquired through the NAPP in 1993. The 1993 NAPP project should provide sufficient data to allow the USGS to resolve remaining technical problems, as well as to work toward a resolution of operational problems in the acquisition, processing, and use of airborne GPS data.

REQUIREMENTS

With the completion of the more than 54,000 7.5-minute, 1:24,000-scale USGS topographic quadrangles, the USGS is facing the task of maintaining these products of the National Mapping Program. Two of the programs that compose the maintenance phase are the planimetric revision of the 7.5-minute quadrangles and the production of 1:12,000-scale DOQ's. The DOQ program provides a current, image-based product, as well as a source of information for revising planimetric 1;24,000-scale data. Ground control requirements for these programs are as follows:

"Supplemental horizontal control spacing in support of

aerotriangulation is required as follows:

> Control will be spaced at a 7.5-minute interval on the project/block perimeter, 15-minute interval on the project/block interior for projects that use National Aerial Photography Program (NAPP) photography..." (USGS, 1992)

Because vertical control requirements to support planimetric revision and DOQ production are much less stringent than the requirements to support 1:24,000-scale, 7.5-minute topographic quadrangle production, photoidentifiable vertical control used in the original topographic quadrangle production (along with map-derived vertical control) is often used in the aerotriangulation of new images.

The NAPP program

The objectives of the NAPP are to provide complete photographic coverage at 1:40,000 scale of the continental United States on a 5-year cycle. Six Federal agencies provide guidance and funding for the program, in cooperation with State agencies. Administration of contracts for the acquisition of photographs is performed by the USGS. An abbreviated list of the current specifications for NAPP photographs are shown in table 1.

Table 1. NAPP Specifications

Description	Specification
Flight Height Above Ground	20,000 ft
Flight-line Direction	North-south
Scale	1:40,000
Format	9X9" quarter quad-centered
Forward Overlap	60%
Sidelap	15-30%
No. of exposures to provide stereo cov. of 7.5' quadrangle	10
Minimum sun angle	30 deg. (may be higher for mountainous regions)

Accuracy Requirements for 1:24,000-scale planimetric revision and 1:12,000-scale DOQ's

USGS products derived from NAPP images must meet national cartographic spatial accuracy requirements. DOQ's produced at 1:12,000-scale are currently required to meet National Map Accuracy Standards (NMAS). NMAS require that not more than 10 percent of points tested be in error by more than 1/30 inch (equal to 33.3 feet or 10 meters on the ground for 1:12,000-scale products) for maps published at scales larger than 1:20,000. Revised maps produced at 1:24,000-scale must adhere to the proposed U.S. National Cartographic Standards for Spatial Accuracy (NCSSA). The NCSSA was developed by the Subcommittee on Base Cartographic Data under the Federal Geographic Data Committee (FGDC). Although the FGDC has approved the new standard, it is proposed to replace the NMAS issued by the Office of Management and Budget (OMB). Therefore, the new standard must also be approved and issued by the OMB. The NCSSA is in the process of a final, public review prior to submission to the OMB.

For a map to be labelled Class 1, according to NCSSA specifications, "...the standard error...in both the x and y coordinates computed separately, shall not exceed ± 0.25 mm., measured at the publication scale." For a 1:24,000-scale map, this means the horizontal standard error must not exceed 20 feet on the ground in either the x or y coordinate. To support these accuracy requirements, the accuracy of positions established using aerotriangulation must be within approximately 2 meters horizontal and 4 meters vertical relative to positions established using ground surveys of a higher accuracy.

USGS AIRBORNE GPS RESEARCH

The work of Lucas and others provided the motivation for the USGS to conduct investigations into the use of NAPP-like images in conjunction with GPS positions of the exposure station to control aerotriangulation. The first of these tests was conducted in cooperation with the Texas Department of Transportation in October 1989. Although the results of this test were positive, photographs with only 10 percent sidelap were acquired, and it was necessary to add map vertical control to bring horizontal and vertical positions derived through aerotriangulation to within 2 and 4 meters, respectively, of positions established using GPS ground surveys. Substantial difficulties were encountered in the collection of the photographs and GPS data because of the lack of satellite availability at the time of the project. The use of airborne GPS within the NAPP was delayed pending further progress toward completion of the GPS satellite constellation. As satellite availability improved, two

additional research projects were planned and executed. These tests, conducted near Phoenix, Arizona, over an approximately 1,500 square kilometer area, provided the USGS with a great deal of practical insight into the capabilities and limitations of airborne GPS. In addition, personnel were familiarized with critical operational aspects of this technology.

The Phoenix Projects

Figure 1 depicts the project area and control distribution for both the 1991 and 1992 missions. Thirty-four photoidentifiable positions were established using Trimble 4000ST GPS receivers in the static positioning mode. As shown in figure 1, control points were established near each 7.5-minute intersection. In addition, two test points were established within each quadrangle. Both horizontal and vertical coordinates were derived for each point using GPS observations collected at a 15-second rate. The data were processed using the program TRIMVEC+ with the broadcast ephemerides. Results were analyzed and adjusted with FILLNET, v. 2.0.

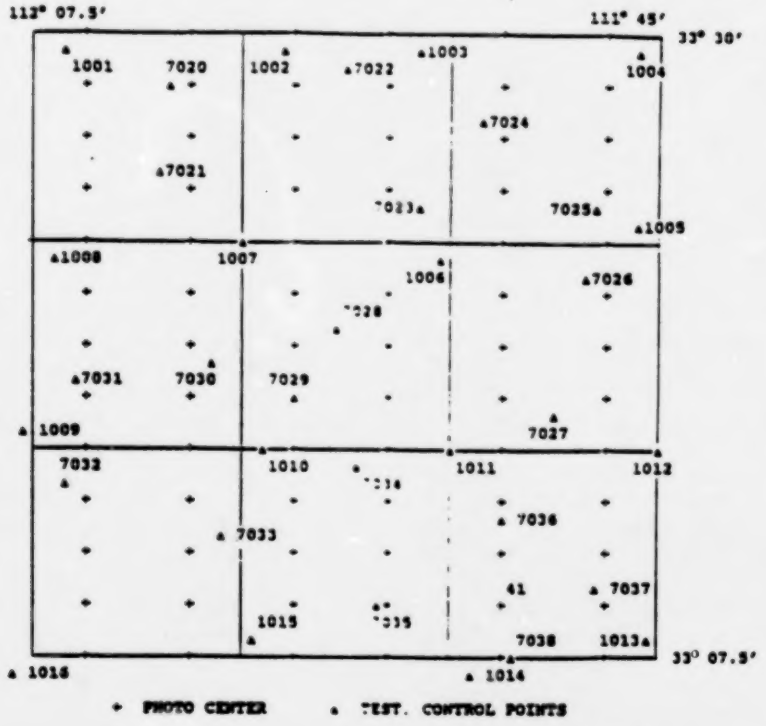

Figure 1. Phoenix project area and control diagram.

Three additional points were located relative to the network of control and test points. An "index point" (station SCOX) was established on the airport runway for the 1991 mission. Positions for two reference points to be used as sites for the location of continuously operating reference trackers were also established: one at the airport (station SCOT), located near the northern boundary of the project area, and one approximately 100 km west of the center of the project area (station TONA).

During the 1991 mission, an Ashtech model LD-XII GPS receiver was operated on board a Cessna 340 aircraft. The antenna was positioned on the aircraft's fuselage, directly above the camera. The offset between the phase center of the antenna and the camera's focal plane was measured using a Wild T-2 theodolite and steel tape. The distance between the focal plane and the front nodal point of the camera was obtained from the camera manufacturer. Ashtech LD- and P-XII receivers, along with an antenna positioned on the vertical stabilizer of the aircraft, were used in the 1992 mission. The antenna was positioned on the vertical stabilizer in an attempt to reduce the effects of multipath. Antenna to camera offsets were again measured with a Wild T-2 and steel tape. For both the 1991 and 1992 missions, the cameras were operated in a "locked-down" position, thus keeping the offset between the antenna and camera constant.

The cameras used in 1991 were the Zeiss RMK Top 15 and LMK 2000. An RMK Top 15 was used for the 1992 mission. In both the 1991 and 1992 projects, camera exposures were recorded as "events" by the GPS receivers so that the precise time for each exposure was known. The time offset between the camera exposure and the record of the event in the GPS data was assumed to be less than 50 milliseconds, based on manufacturers' testing. GPS observables recorded for the 1991 and 1992 missions are shown in table 2. The sampling rate for both missions was 1 second and the mask angles set for 2° on the aircraft and 5° at the ground reference stations. Flights were planned so that a minimum of five satellites would be in view at the time of the mission.

GPS data were postprocessed (processed after the conclusion of the mission) using the OMNI software, developed at NOAA, for double difference carrier phase processing, and the PPDIFF software, developed by Ashtech, for differential GPS processing by corrections to pseudoranges smoothed with the aid of the carrier phase. The results of both the OMNI and PPDIFF processing were positions at the antenna on the aircraft for each 1-second epoch, established relative to one of the reference stations on the ground. Processing was completed for several missions relative to more than one ground reference station so that results could be compared. The positions

Table 2. GPS Observables

1991	1992
L1 C/A code phase L1 carrier phase L2 carrier, codeless (half-wave)	L1 C/A code phase L1 carrier phase L1 P-code phase L2 carrier phase, P-code (full-wave) L2 carrier phase, codeless (half-wave) L2 P-code phase

established using the OMNI software were estimated to be accurate within approximately 10-20 centimeters (1 sigma) and the positions established using the PPDIFF software were estimated to be accurate within 1-2 meters (1 sigma).

The program GAPCET, also developed at NOAA, was used to interpolate positions of the antenna at the time of exposure of the camera. These interpolated positions were then provided as input to the General Integrated Analytical Triangulation Program (GIANT), version 3.1. This version of GIANT allows input of antenna to camera offset measurements and standard input, including image measurements, camera calibration information, and ground coordinates for points to be used as control in the adjustment.

Numerous adjustments were performed for the study area to compare the results obtained while varying (1) the amount and type of ground control used to constrain the adjustment, (2) the accuracy of GPS positions of the antenna on the aircraft (OMNI vs PPDIFF processing results), and (3) the reference station used in GPS data postprocessing. One adjustment was performed in the conventional manner, without the use of GPS-derived positions of the cameras and using ground coordinates for control points. In all cases, test point positions established in the GPS ground survey were withheld from the block adjustment.

Figures 2, 3, and 4 are plots of differences in test point coordinates established by block adjustments versus coordinates for the same points established in the GPS ground survey. All figures are derived from data collected in a single mission, using the ground reference station (SCOT) at the airport. Figure 2 shows the results of the conventional aerotriangulation using no GPS-derived camera positions and ground control at 7.5-minute intersections. Figure 3 shows the results of the aerotriangulation using camera positions established through PPDIFF processing (positions estimated to be accurate within 1-2 m) and vertical control at 7.5-minute intersections and along the northern and southern boundary of the block. Vertical

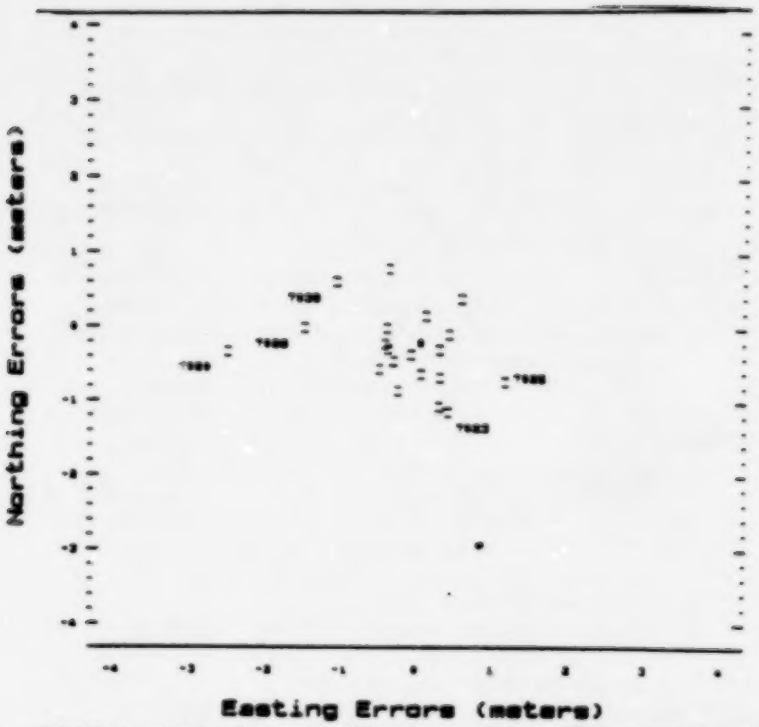

Figure 2. Differences in coordinates from GPS ground survey and those from GIANT adjustment completed without GPS-derived positions of exposure stations and with a conventional control configuration.

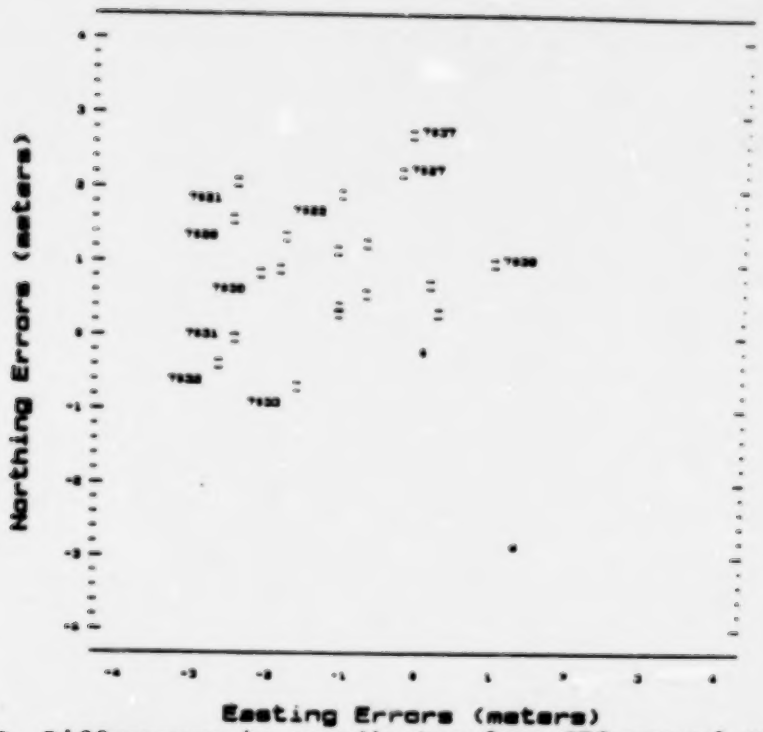

Figure 3. Differences in coordinates from GPS ground survey and those from GIANT adjustment completed using positions of exposure stations derived from PPDIFF and using vertical control.

coordinates were derived from both the GPS ground survey and USGS 7.5-minute topographic quadrangles and were weighted in the block adjustment to appropriately reflect the method used to derive them. Figure 4 shows the results of the aerotriangulation constrained only by the positions of the camera exposure stations derived from the OMNI postprocessing results. Results displayed in figures 2-4 are summarized in table 3. In all cases the results are within the required accuracy for DOQ production and 1:24,000-scale planimetric revision. It should be noted, however, that additional vertical control was necessary to bring the PPDIFF results within specifications. Without the added vertical control a bias of approximately 6 meters in the vertical component of test point positions was observed.

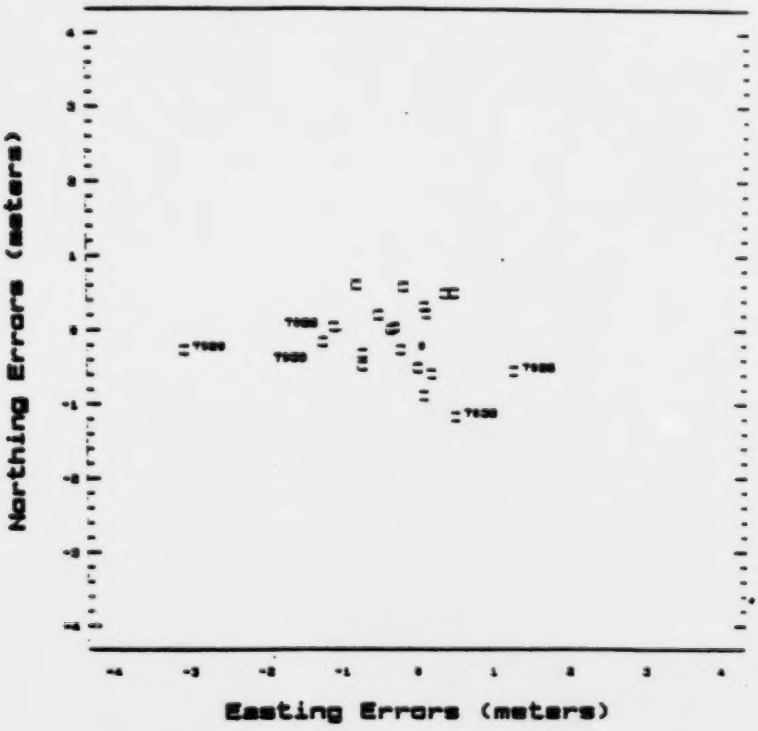

Figure 4. Differences in coordinates from GPS ground survey and those from GIANT adjustment completed using positions of exposure stations derived from OMNI (double difference carrier phase processing) and no ground control.

Table 3. Differences between test point positions established through aerotriangulation and positions established using GPS ground survey (in meters)

	Conventional	PPDIFF	OMNI
Easting	0.8	1.8	0.9
Northing	0.6	1.4	0.5
Vertical	0.9	0.8	1.4

Although the results summarized in table 3 were derived from data collected in a single 1991 mission, they are representative of results obtained for other missions flown in 1991 and 1992. Results of block adjustments performed using camera positions established relative to the TONA ground reference station, located approximately 100 km to the west of the center of the project area, were not significantly different from results obtained using reference station SCOT.

The main conclusion derived from the Phoenix projects was that acceptable results could be obtained from aerotriangulation of NAPP images controlled by GPS-derived positions of camera exposure stations. Although in some cases additional ground control was necessary to bring aerotriangulated positions to within acceptable accuracy limits, highly accurate GPS-derived camera positions seemed to reduce the need for additional ground control. Based on these conclusions, a limited project was undertaken within the NAPP to contract for delivery of GPS positions for camera exposure stations in addition to the NAPP images for the project area.

The NAPP Utah Project

The project area for which GPS-derived camera positions were included as deliverables along with NAPP images covers approximately one-third of the State of Utah, between 110° 45′ and 112° 15′west longitude. This area was chosen because of a favorable satellite configuration prediction during the flying season, as well as the mountainous terrain that covers much of the project area. Specified deliverables for the contract include (1) GPS observations in equipment-dependent raw format, (2) GPS observations in the RINEX format, (3) a flight mission log for GPS observations, (4) GPS processing solution and adjustment output files, (5) GPS-determined coordinates and associated data for each camera exposure station in the GIANT

aerotriangulation software input format, and (6) a postmission summary of the analysis for each flight mission. GPS-determined coordinates for camera exposure station positions were required to be within ± 30 centimeters (1 sigma) horizontal and ± 60 centimeters vertical. These coordinates were also to be determined by processing relative to at least three reference stations on the ground. The intent of this requirement was to provide redundancy and a means by which to check positions without having to perform a conventional aerotriangulation to establish whether camera station positions met accuracy requirements.

At the time of writing this article, the initial collection of images and GPS data over the project area had been completed by Horizons, Inc., and processing of GPS data were underway. A test project similar in size to the Phoenix projects is planned for an area near Salt Lake City. This project will provide additional information about the accuracy of GPS-derived camera station positions and will allow standardized production procedures to be developed.

FUTURE PLANS AND CONSIDERATIONS

Future plans to incorporate airborne GPS-derived camera positions into cartographic production procedures include completion of processing and testing of the Utah data and contracting for collection of GPS data along with NAPP images in 1995. Because the major motivation for using this technology is to reduce the cost of acquiring ground control to support aerotriangulation, cost comparisons derived from several projects will be necessary to make valid judgements concerning cost-effectiveness. As operating procedures become more standardized, it is expected the cost associated with the collection and processing of GPS data to derive camera positions will become a small percentage of the total cost of image acquisition. This is particularly true in light of the increased use of the GPS as a navigational tool. Additionally, as a national network of continuously operating ground reference stations becomes available, it will not be necessary for the government or the NAPP contractor to establish and operate independent stations.

In summary, some technical questions concerning the use of GPS-derived exposure station positions in a production environment for large areas remain to be resolved. The optimum accuracy of exposure station positions necessary to keep ground control to a minimum must be determined, given current NAPP flight mission parameters. Additionally, the required rate at which GPS observations must be recorded to achieve the necessary accuracy must be determined so that the volume of data collected is not unnecessarily large. Determination of these critical technical specifications will play a role in determining the cost of acquisition and processing of GPS data under the NAPP. When technical

questions are resolved, standardized specifications for acquiring GPS-derived coordinates for NAPP images can be developed and operating procedures put in place.

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NEW TRENDS IN TECHNOLOGY, AND THEIR APPLICATIONS: DIGITAL DATABASES, GEOGRAPHICAL AND LAND INFORMATION SYSTEMS

Implementing the Spatial Data Transfer Standard

Paper submitted by the United States of America**

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** Prepared by Kathryn C. Wortman, U.S. Geological Survey.

INTRODUCTION

Recent advances in geographic information system (GIS) technology and digital cartography have increased the demand for digital spatial data. Unfortunately, the diversity of existing hardware and software and the lack of data exchange standards have inhibited the transfer of spatial data between data producers and data users. The Spatial Data Transfer Standard (SDTS), or Federal Information Processing Standard (FIPS) 173, was designed to facilitate data transfer between dissimilar spatial data bases. Implementation of the SDTS will increase access to and sharing of spatial data, will reduce the cost of developing data bases, and will improve the quality and integrity of spatial data and related documentation. In addition, the SDTS will reduce duplication of effort in data production and maintenance and will make a national spatial data infrastructure feasible.

STATUS

In April 1991, after nearly 10 years of development and testing, the SDTS was issued by the National Institute for Standards and Technology (NIST) as a proposed FIPS. Following a 90-day formal public review and comment period, the Technical Review Board (TRB) overseeing the development of the SDTS met to review the comments. The document was then edited according to decisions made by the TRB. The edited SDTS was sent to the Department of Commerce for processing as a FIPS in February 1992; approval was granted on July 29, 1992. The SDTS implementation was effective February 15, 1993; use of the standard was mandatory for Federal agencies 1 year from this date -- February 15, 1994.

The SDTS, or FIPS 173, will serve as the spatial data transfer mechanism for all Federal agencies and will be available for use by State and local governments, the private sector, and research and academic organizations. The success of any standard, such as the SDTS, depends on its acceptance by the user community. Therefore, the U.S. Geological Survey (USGS), as the designated SDTS maintenance authority, is committed to providing support to the greatest extent possible to increase access to and use of the standard.

SUPPORT FOR USE OF SDTS

The USGS has identified several activities to promote acceptance and use of the SDTS. An SDTS Task Force was established to coordinate these activities within the USGS and throughout the spatial data community. These activities include: overall program coordination, NIST support, profile development, software development, training, education, and marketing activities, and SDTS Spatial Features Register development.

Program Coordination

Program coordination involves developing support activities within the USGS, facilitating similar activities outside the USGS, and interfacing with related standards development activities in the spatial data community, both nationally and internationally. The USGS is actively working with the Federal community, through the Federal Geographic Data Committee (FGDC), to foster

support for SDTS implementation. Coordination with the FGDC working groups and subcommittees is focused on such activities as profile development, metadata definition, and feature and attribute data dictionary definition. The USGS is also working with many professional societies (e.g., Association of American Geographers (AAG), American Congress on Surveying and Mapping (ACSM), Automated Mapping/Facilities Management (AM/FM), American Society for Photogrammetry and Remote Sensing (ASPRS), the Institute for Land Information (ILI), and the Urban and Regional Information Systems Association (URISA)), the National Academy of Sciences Mapping Sciences Committee, and research organizations to encourage use of the SDTS for data exchange. Special interest groups, such as the Intelligent Vehicle Highway Systems America, are working with the USGS to define strategies to implement the SDTS within their systems and throughout their user community. The USGS is also supporting the U.S. Army Corps of Engineers Construction Engineering Research Laboratory in developing an SDTS interface to the Geographic Resources Analysis Support System (GRASS). The GRASS is a GIS that is used by a variety of public and private agencies. Lastly, many States are actively involved in GIS standardization activities, including the implementation of the SDTS as the mechanism for data exchange, standardizing data documentation, and standardizing feature and attribute terms and definitions.

The USGS is coordinating with other data standardization activities in the United States, most notably within the Defense Department, the National Ocean Service (NOS) within the National Oceanic and Atmospheric Administration (NOAA), and the National Aeronautics and Space Administration (NASA). The Defense Department's Defense Mapping Agency (DMA) represents the United States on the Digital Geographic Information Working Group (DGIWG), an ad-hoc group made up of member countries from the North Atlantic Treaty Organization (NATO). NATO adopts the DGIWG standards recommendations. The DGIWG recently developed the Digital Geographic Information Exchange Standard (DIGEST) for its user community. NOS supports the use the of DX-90 standard for International Hydrographic Organization data applications. NASA supports the use of the Hierarchical Data Format (HDF) as the exchange format for the products to be created by the Earth Observing System Data and Information System program. The USGS is involved in efforts with the DMA, NOS, and NASA to harmonize the SDTS with the DIGEST, the DX-90, and the HDF, respectively, to ensure compatibility between these standards.

NIST Support

This activity is required for the continued maintenance and growth of the SDTS. When the SDTS was approved as a FIPS, it entered a 5-year maintenance cycle, at the end of which it will be possible to modify the standard to meet the changing demands of the user community. Because of its modular design, the SDTS can be changed and expanded as the requirements for its use change. Also, the American National Standards Institute (ANSI) recently formed a GIS Technical Committee, known as X3L1. X3L1 will work to adopt the SDTS as an ANSI standard. The ANSI approval of the SDTS will broaden acceptance and use of the standard within the United States and will serve to represent the SDTS in international standardization activities, most notably within the International Standards Organization (ISO).

Profile Development

The development of profiles is a key element for the successful implementation of the SDTS. A profile is a clearly defined and limited subset of the standard that is designed for use with a specific type of data. The SDTS contains a full range of capabilities and options designed to handle a wide spectrum of possible geographic and cartographic data structures and content. Because handling this range of options is such a difficult task for encoding and decoding software, the best way to implement the SDTS is to first define a profile with few, if any, options. Software can then be designed to handle just these options. Regardless of which options are specified for a given profile, all profiles will share important common characteristics, particularly in terms of global information or metadata, and physical file encapsulation methods.

The USGS is coordinating the development of profiles with the user community to ensure maximum consistency among all SDTS profiles. The first of these profiles, the Topological Vector Profile (TVP), was tested and reviewed in 1992 to ensure that it supported vector data with planar graph topology. This profile was submitted to the NIST in early 1993 for approval as an amendment to the SDTS; the TVP will be issued as part 4 of the SDTS effective February 15, 1994. At this time, USGS digital line graph (DLG) data will be available from the National Digital Cartographic Data Base in the TVP.

Additional vector profiles are being addressed, such as one for network-only topological data sets useful in transportation and utility systems and one for site and location data sets useful in geology, mining, and exploration systems. The TVP will provide the foundation for future vector profile development; changes will be incorporated when necessary to support the required data structures.

The development of a raster profile began late in 1992; this effort is expected to continue through mid-1994. An official test and demonstration period (June to November 1993) produced an approved core raster profile for the SDTS. The USGS has made an uncompressed digital orthophoto quarter-quad (DOQ) available in the prototype SDTS raster profile. The USGS also plans to make available digital elevation model (DEM), compressed digital orthophoto quad (DOQ), and advanced very high resolution radiometer (AVHRR) data sets in the prototype SDTS raster profile to support additional testing. This raster profile will be completed and forwarded to the NIST for approval as part 5 of the SDTS by mid-1994.

Although this core raster profile developed thus far can support a variety of data sets, additional raster data requirements in the areas of n-dimensional arrays, raster compression, spatial referencing, and color indexing are being addressed and will ultimately expand this core raster profile. These additional requirements will enhance the capabilities of the core raster profile to support the large number of satellite data produced by NASA and NOAA, which are vital for global change research projects supporting environmental monitoring. The raster profile has the potential to support and make a large amount of valuable global spatial data available to a wide range of users.

Software Development

The development of software is an integral part of implementation. Software tools, such as encoding, decoding, and display tools, must be developed. The vendor community will assume a large part of this responsibility. The USGS is designing a spatial data transfer processor to support SDTS exchanges of its own digital spatial data, such as DLG's, DEM's, and DOQ's. The USGS has also developed public domain software tools, known as the FIPS 123 Software Library, designed to support the encoding and decoding of logically compliant SDTS data in and out of the required ISO 8211/FIPS 123 physical file implementation. This software is available to the vendor community to support their development of turnkey systems that import and export SDTS data.

The USGS is working with the NIST to define and implement a conformance testing, or certification, program. As part of this activity, the USGS will develop software tools and test data to validate a system's capability to either encode or decode SDTS data sets, based on one of the approved profiles. The USGS and the NIST will work to define a conformance testing plan for each SDTS profile. Each plan will identify test points (what is to be tested) and procedures (how it is to be tested). Test plans, software, and data sets will be made available to vendors so that they may pre-test their translators during system development. Upon request, vendors can have their systems formally tested for SDTS conformance. Systems that pass conformance testing will receive NIST certification.

Training, Education, and Marketing Activities

Training, education and marketing activities are needed to increase the knowledge and understanding of the SDTS within the community. The SDTS is a technical specification describing content, structure, and format; it is not an easy document to understand. To address the complexity of the document, user guides are being developed for the standard, the profiles, and the software tools. The USGS will coordinate the development of these user guides over the next few years. In addition, the USGS is developing other training aids, such as PC-based training tutorials and educational video tapes.

Education of the spatial data community and promotion of the SDTS will continue to be supported by the USGS through workshops and other presentations. Presentations on the SDTS and associated activities are planned for the major professional organizations, such as the AAG, the ACSM, the ASPRS, AM/FM International, the ILI, and the URISA. In addition, the USGS, the NIST, and the Standards Working Group of the FGDC plan to sponsor workshops to provide detailed information about the standard and implementation strategies.

Spatial Features Register

One part of the SDTS presents a standard model for a spatial features data dictionary, as well as a glossary of terms and definitions for entities and attributes. This entity and attribute glossary provides a foundation for standardizing spatial features. The glossary now contains only a limited set of hydrographic and topographic features. Because this glossary is not complete, conformance is optional in the prototype TVP; however, conformance to the model is mandatory. For the glossary of SDTS to be useful, additional

terms and definitions must be included for other categories of data, such as cadastral, geodetic, and geologic, and the set of hydrographic and topographic features must be expanded. The NIST authorized the USGS to establish an SDTS Spatial Features Register to expand the content of this glossary. The Federal community will contribute information for this register through the data category subcommittees of the FGDC; however, the USGS intends to solicit information from the non-Federal spatial data community as well. A plan to maintain the Spatial Features Register is being developed. Because the register will allow users to update the glossary continuously, this part of the SDTS will evolve over time.

CONCLUSION

The Department of Commerce's approval of the SDTS as a FIPS is a major milestone for the spatial data community. Although the USGS is committed to coordinating a wide range of activities designed to promote acceptance of the SDTS, all members of this community must contribute to these efforts to ensure success of the standard. For additional information concerning the SDTS, or FIPS 173, or how to participate in these activities, please contact:

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Item 5 (d) of the provisional agenda*

NEW TRENDS IN TECHNOLOGY, AND THEIR APPLICATIONS: DIGITAL DATABASES, GEOGRAPHICAL AND LAND INFORMATION SYSTEMS

The U.S. National Spatial Data Infrastructure: continuing evolution

Paper submitted by the United States of America**

* E/CONF.87/1.

** Prepared by Nancy Tosta, U.S. Geological Survey.

INTRODUCTION

In a report published in 1993, the Mapping Science Committee (MSC) (1993) of the National Research Council defined the National Spatial Data Infrastructure (NSDI) as the "means to assemble geographic information that describes the arrangement and attributes of features and phenomena on the Earth. The infrastructure includes the materials, technology, and people necessary to acquire, process, store, and distribute such information to meet a wide variety of needs."

The term "spatial data," as used in the concept of the NSDI, refers to data that can be registered to a location on the surface of earth by a georeferencing system, such as latitude/longitude or through indirect referencing such as street addresses. These data are called geospatial data. The amount of geospatial data in the United States and the world is increasing at an exponential rate because of the proliferation of electronic recording instruments such as those carried on satellites or onboard ships, because of the use of geographic information systems (GIS) and global positioning systems (GPS), and because of the availability of high resolution, high speed scanning equipment. Such collection efforts have been spurred by the increasing number of relatively low cost, reliable computers and their ability to process, analyze, and display vast amounts of data.

Examples of geospatial data are (1) raster data such as satellite images, grids of topographic or sounding data, side scan sonar data from the seafloor, and images of maps or charts that have been electronically scanned; and (2) vector data such as lines defining highways, land use, administrative and international boundaries, hydrology, and shorelines.

Concerns have grown in the United States about the limited availability of digital geospatial data that are accurate, current, and the appropriate resolution. Other concerns have focused on the large sums of money, estimated to be $8 - 10 billion globally, that are expended annually on geospatial data by governments and the private sector. Recently, the Office of Management and Budget (OMB) conducted a data survey and determined that more than $4 billion is spent annually by U.S. Federal agencies on the collection, management, and dissemination of geospatial data. The questions raised are: Where are all those data? Why are they so difficult to find? When found, why are they difficult to use? Can they be integrated? Who maintains them?

The interaction of data producers and users in the United States is not the same as that in other parts of the world. Data are treated differently by the U.S. Government than almost any other institution in the world. For the most part, geospatial data produced at taxpayer's expense to meet the needs of the Federal Government are made available to anyone for the cost of dissemination. Data are not copyrighted (with some exceptions) and are free for redistribution, repackaging, or reformatting by others. Data sharing, at minimal or no cost, is a common practice among thousands of organizations. At local levels of government in the United States and in most other parts of the world access to geospatial data is much more controlled through copyrights and full-cost recovery policies.

There are numerous debates between levels of goverments in the U.S. and between the U.S. and other nations about the potential benefits and costs of making digital geospatial data more easily available. Given limited resources, how can more data be made available? Should data be freely distributed or should fees be levied? Does controlling access and charging for data improve data quality and availability? Are resources too limited to "give" data away? As the global information infrastructure contributes to increasing availability of digital data, issues of ownership, intellectual property rights, and data fees, will become even more complex.

In many ways, U.S. Government policies of freedom of access to data, are creating a greater need for coordination. The spread of technology and ease of data access have created an environment in which thousands of organizations require and produce data for use, sale, and distribution. Numerous data sets are available but they differ in accuracy, completeness, currency, and cost. Users have a difficult time finding and sorting through data to determine what might best meet their needs. Data producers often duplicate each others' efforts. Better means of collecting, organizing, finding, and sharing data are required to maximize investments being made in geospatial data.

About three years ago, discussions began on the need for better national coordination and organization among data users and producers. The concept of an NSDI was proposed by the MSC, as mentioned above. The NSDI is conceived to be a set of policies, procedures, standards, organizations, and data that contribute to the ability to more efficiently make use of and conduct analyses on geospatial data. Such an infrastructure would serve to integrate geographic information about features on the Earth. In the Fall of 1993, the Clinton-Gore administration identified the development of the NSDI as a key initiative for helping to reinvent government. The Federal Geographic Data Committee (FGDC), mandated by the

OMB, was charged with the responsibility of raising funds and overseeing partnerships with State and local governments and the private sector to facilitate NSDI efforts nationwide. In recent months, Secretary of the Interior Bruce Babbitt has assumed the chairmanship of the FGDC, raising the visibility of the NSDI within Federal agencies and across the Nation.

NSDI ACTIONS

Four main areas of action have been initiated to assist in developing the NSDI. The first is identifying needed standards and overseeing their development and implementation. The second is producing a framework of basic digital geospatial data from which other data can be derived or to which other data might be registered. The third is producing critical national digital thematic data sets, and the fourth is the development and evolution of the National Geospatial Data Clearinghouse. These activities are not mutually exclusive.

Standards

Standards are considered onerous by many who feel that they are too time consuming and overly complex. But the benefits can be significant. If, for example, standards did not exist for traffic patterns and road signals, far more accidents would occur. In other areas, standards for clothing and shoe sizes, building materials and batteries, for example, decrease costs and promote interchangeability. This does not mean that everyone has to wear the same size or color, live in identical houses, or buy identical electronic devices. Standards do not have to be that stringent. Standards are generally meant to facilitate, not control or dictate.

Similarly for geospatial data, there is not one size, accuracy, or common representation of geography that will fit all. But commonalities exist, and for many applications, common geographic resolutions and representations will suffice. Budgets often dictate using data that already exist, rather than designing projects around unique requirements. If a variety of digital geospatial data producers can agree to certain standards for how data will be collected and formatted, the ability to use these digital geospatial data would be greatly improved. This concept is addressed further in the framework data section.

Various subcommittees of the FGDC are working on data content standards that will help define how to map and classify specific themes of data such as topography and bathymetry, soils, wetlands, cadastral, and transportation. This effort does not mean that there are not

unique requirements for certain characteristics of these themes. But underlying most of these themes will be some commonality in definitions of classes and characteristics that will work for the majority of geospatial data users. Many users about to collect digital geospatial data related to one of these themes would find it useful to have guidelines from agencies who have studied these mapping activities. The standards will evolve as new tools and technologies for data collection affect what can be collected cost effectively and as more information must be integrated for more complex spatial analyses.

Additionally, standards that facilitate finding and accessing data are critical in today's world of rapidly increasing volumes of information. Data dissemination requires consistent, planned data management practices, such as documentation and archiving. Data that are unavailable do not contribute to human knowledge. The electronic highways of the future will carry terabytes of geospatial data. The ability to sort and filter through all of these data, extracting those that are most fit for use, is a requirement of the NSDI.

The FGDC is working on documentation or metadata standards to provide context for any geospatial data set. Additionally, transfer standards have been developed to facilitate use of data in different software systems. The spatial metadata standard is in the final stages of testing prior to release as an FGDC standard. This standard will most likely be submitted to the National Institute of Standards and Technology for adoption as a Federal Information Processing Standard (FIPS). The Spatial Data Transfer Standard (SDTS) has already been adopted as a FIPS. As of February 1994, Federal agencies are required, at a minimum, to make their data available to outside organizations in an SDTS format and to specify compliance to the standard in procurement of services from private sector vendors.

Framework Data

The fact that many users have common needs for digital geospatial data sets is germane to the concept of framework data. As spatial analyses are conducted, numerous users depend on certain geographic representations, either to reference the collection or display of other data or as variables for analysis. The U.S. Geological Survey products, such as 1:24,000-scale quadrangle maps, have formed a foundation in the analog world for geospatial data collection activities and analyses. Similarly, certain sets of digital data can form a framework for GIS analyses. If standardized digital geospatial data at 1:24,000 scale (roughly an accuracy of $\pm$ 12 meters) were complete for the Nation, a framework would exist on which to build many other data sources. The only complete national data bases are, however, at less accurate resolutions and are not current. An example is the Census Bureau's 1:100,000-scale TIGER (Topologically Integrated Geographic Encoding and Referencing) data having an accuracy of $\pm$ 50 meters.

At present rates of public investment for digitizing geospatial data, a national data base at a resolution and complexity comparable to the 1:24,000-scale quadrangles will not exist for decades. However, numerous disparate organizations are producing high resolution data (greater than 1:24,000 scale) over small geographic areas. Assuming these data meet some minimal level of standards, if they could be identified, made accessible, and "linked" together, major steps toward development of a framework might be accomplished. Given the lack of trusted, consistent data, or lack of knowledge about the existence of data, many

(perhaps thousands) of users are independently digitizing or capturing data at a variety of resolutions, in ad hoc, nonstandardized, one-shot approaches. Other users are working with new technologies such as GPS and digital ortho imagery (both satellite and photography), in an effort to more accurately represent geography.

The FGDC has created a working group to discuss the value to the Nation of implementing a minimum framework of maximally useful digital geospatial data in the shortest time possible and to define the characteristics of a framework. These discussions could lead to various agencies working to produce minimum versions of certain digital geospatial data sets as fast as possible. These data sets would be of a nature and resolution required by most people in a given geographic area. For example, framework data sets might include digital ortho imagery, elevation, and vector representations of transportation, shorelines, hydrology, or boundaries, at resolutions that would vary by geography, with higher resolution in urban areas and lower resolution in rural areas. Basic spatial representations of these themes would form the framework, such as delineations of transportation "pathways." More details about these "pathways" - for example, whether a pathway is a dirt road or 10-lane highway or a railroad - might be derived from other sources and referenced to the framework. The goal is to create a standardized, "trusted" geospatial framework within a short time to eliminate redundancy and duplication in data collection efforts and to minimize the difficulties of data integration through some common spatial denominators.

Many users are primarily interested in application-specific data, but large amounts of time are spent trying to find, collect, and organize basic framework information about roads or boundaries, for example. The FGDC is attempting to provide an organizational structure within which debates about how to approach these kinds of issues can be held and standards can be defined. If there could be more coordination in the collection of data to meet multiple users' needs, duplication could be minimized and more sophisticated data inventories over the same geographic area could be produced based on available funding.

Thematic Data Sets

The thematic data set component of the NSDI concerns those data that are required with some consistency on a national basis, but do not form the foundation for other data or are not necessarily required by most users, as in the case of framework data. The ability to collect or display thematic data often depends on the availability of framework data. Example thematic data sets are soils, land cover, and wetlands. Although these data may not be required by most users, there can be value in coordination of data collection practices. For example, there are national programs to protect wetlands which rely on the ability to accurately assess the extent and location of wetlands in a consistent fashion. Many local programs, however, also have wetlands assessment and management requirements, often demanding more detail than national efforts, so data collection and classification approaches vary. Different wetland classifications, criteria, and data collection techniques result in incompatible data sets, an inability to integrate data, and ultimately different estimates on the extent and condition of wetlands. Efforts are underway within the Wetlands Subcommittee of the FGDC to reconcile these discrepancies. The ability to aggregate a variety of data sets, through the use of agreed-upon standards, would enhance the availability of current data and provide data that are consistent and useful in multiple contexts. Expecting that a single

agency can compile and maintain data for the entire Nation within a meaningful timeframe is no longer reasonable. Changing the current situation requires standards, close coordination, data sharing, open data access policies, and trust in the data production efforts of other agencies.

National Geospatial Data Clearinghouse

The last, but hardly least important, component of NSDI is the clearinghouse. This is an effort to use the existing and rapidly expanding information infrastructure to facilitate access to geospatial data. This clearinghouse is distributed in nature, meaning there is not a centralized "warehouse" of geospatial data. Thousands, potentially millions, of data holdings will be cataloged and accessed across electronic networks.

There are three elements to the operation of the clearinghouse. The first is the FGDC spatial metadata standard. Data producers nationwide, at all levels of government and within the private sector, will be encouraged to document or describe, with the spatial metadata standard, any data they produce. This documentation will then be made electronically accessible on Internet. The Internet is the second element. Internet has become the most pervasive electronic network in the world, with an estimated 15 million users, and growth rates of 20 percent per month. This network of networks will continue to evolve and change as the private sector plays a larger role in the information infrastructure. Federal agencies, as well as other spatial data producers, are being encouraged to establish Internet connections. The third element of the clearinghouse is software tools for searching and querying data on the network. The FGDC has been testing wide area information servers (WAIS) software, which is built on a library standard (Z39.50) for searching and querying. WAIS was originally designed to conduct text searches, but has been enhanced to provide the ability to conduct geographic searches based on specifying the coordinates that cover an area of interest. New tools are continually being developed and offered to the public over the Internet. Recently, Mosaic, which provides the ability to build hypertext links between sources of data, has gained great popularity as a user interface for "surfing" the net. These three elements: metadata, Internet, and searching tools, together provide the ability to electronically document, serve, search for, browse, and access geospatial data that vary in scope, context, format, detail, and location.

In 1994, training and workshops about using the metadata standard, serving data, and using search and query tools are being offered by the FGDC. The success of the clearinghouse is dependent on participation. Telephones would not be particularly useful or deemed a success if few people used them. The clearinghouse is dependent on thousands of individuals modifying their behavior to more effectively manage their data, and doing so in a coordinated manner.

NSDI PARTNERSHIPS

Underlying all of these components of the NSDI is the need for creative partnerships. The NSDI builds on existing and yet-to-be formed institutions and relationships to facilitate the ability of the geospatial data community to share information and to develop and maintain

standard data sets. Progress and success of the NSDI will depend on participation from all levels of government, the private sector, and academia from all regions of the country.

In May 1993, the FGDC and various Federal agencies; GIS hardware, software and integration firms; and the major GIS professional societies in the United States sponsored the first National Geo-Data Policy Forum (1993). Individuals from government agencies, private corporations, and academia examined policies related to the NSDI and debated appropriate means of interaction to further the NSDI. No consensus exists on issues such as data ownership, privacy, copyrights, and data production responsibilities. The forum, however, provided the opportunity to identify issues and conduct constructive debates. The forum is likely to become a biennial event, with the next one scheduled for May 1995.

The forum was followed by public meetings held in conjunction with such major industry events as the Urban and Regional Information Systems Association annual conference, and the GIS/LIS conference. Each of these events provided a means to debate issues from a variety of public and private perspectives. Agreement exists that the policies for developing the NSDI must respond to the changing roles of the private and public sectors, must identify more creative ways for various communities to work together, must remove impediments to cooperation, while at the same time minimizing bureaucracy.

Within the Federal Government, support for the NSDI continues to grow. The Clinton administration endorses the vision of open access to public information and shared responsibilities in the development and use of that information. Vice President Gore's National Performance Review recommended the establishment of the NSDI as a national initiative to be based on partnerships with State and local governments and the private sector. The characteristics of a functioning NSDI - integration of different disciplines and efforts, along with a cooperative community spirit - are the same as those needed for government and society in dealing effectively with the challenges of the 21st century.

Opportunities for constructive communication and cooperation are needed. Partnerships work only if agencies, governments, and private companies have opportunities to interact, identify common concerns, and define needed products. The FGDC is conducting discussions at most of the major U.S. GIS conferences in 1994 and is working to optimize the various committee structures within FGDC to include non-Federal representation as appropriate. Additionally, State and regional councils and forums that consist of Federal, State, and local government and private and academic interests are being encouraged to facilitate dialogue on data needs and options for collecting and sharing information over areas of common geography. Such issues as the habitat concerns of the spotted owl or responding to the 1993 Mississippi River flood are geographically specific and involve many different institutions. More interactions to cooperatively build and manage shared data sets to respond to these geographically based concerns must be fostered.

All of these activities are very dependent on improved communication. At the Geo-Data Policy Forum, many people asked, "Who's in charge?" Perhaps this has become a world where that is no longer a relevant question. The interaction of computers and telecommunications is changing traditional philosophies on many things, but particularly

organizational hierarchies, economies, and information ownership. The increasing complexity of environmental, economic, and social problems on a global basis is forcing a reexamination of the interactions among individuals, governments, other sectors, and other nations. New ways to interact must be found to build new institutions and identify new leaders, all in a world where no single organization or institution is in charge. Cooperation and coordination based on respect and consensus building, rather than on dictating, demanding, or controlling, are critical to the success of the NSDI.

CONCLUSION

The concept of an NSDI has gained far-reaching acceptance within the geospatial data community. The FGDC has identified a number of actions that will assist in evolving the NSDI, but progress is dependent on the participation of thousands of disparate and separate individuals, organizations, and institutions. The ability to agree on and implement standards, to define commonly needed data sets, to share information, to communicate electronically, and to trust other agencies, are critical steps in building a successful NSDI.

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Item 5 (d) of the provisional agenda*

NEW TRENDS IN TECHNOLOGY, AND THEIR APPLICATIONS: DIGITAL DATABASES, GEOGRAPHICAL AND LAND INFORMATION SYSTEMS

The challenges of air traffic control graphics for the Advanced Automation System

Paper submitted by the United States of America**

* E/CONF.87/1.

** Prepared by Ronald M. Bolton, Chief, Aeronautical Chart Branch, National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, Maryland.

INTRODUCTION

In 1981 the Federal Aviation Administration (FAA) developed a comprehensive plan to improve air traffic control (Figure 1) and airway navigation facilities and services. The Advanced Automation System (AAS) is the most complex element and the centerpiece of this $12.2 billion plan. Officials working on the AAS have stated that it will dwarf the Apollo space program in technical complexity (Richardson, 1990). It includes Common Console (CC) workstation equipment for enroute and terminal operations, new workstations for airport towers, and new software and hardware for tower, terminal, and enroute operations.

The first phase of the AAS will be implementation of the Initial Sector Suite System (ISSS), which includes approximately 7500 CC's. The ISSS will provide air traffic controllers with all present capabilities and several new ones in a more responsive and reliable environment, but requires data in a digital format. The Aeronautical Charting Division (ACD) of the National Ocean Service (NOS) presently supplies thousands of paper charts to the FAA and general public. The ACD will convert these charts to digital format and provide them to the FAA on the same 28 day, 56 day and 6 month cycles as the paper charts.

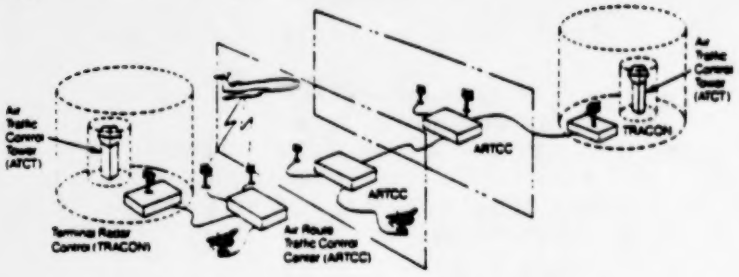
The FAA developed the AAS to improve the safety, capacity, and productivity of aviation services through increased automation (Leyden, 1988). Over 500 million people per year presently use the National Airspace System (NAS), and that figure is projected to increase to over 750 million by the century's end ("The FAA's National Airspace Plan: Meeting the Challenge"). This will place an intolerable strain on the existing air traffic control system.

The FAA awarded International Business Machines (IBM) a $3.6 billion contract to develop the AAS through a new generation of air traffic control hardware and software (McCormick and Messmes, 1988). The FAA has already set the stage for the transition to the AAS by installation of new IBM mainframe computer systems in all 20 domestic enroute control centers (FAA-AP-1990-4906, 1990).

COMMON CONSOLE DESCRIPTION

The CC (Figure 2) is a new workstation for enroute and approach air traffic control. It will replace existing consoles, computer readout displays, flight data input/output devices, and flight strip printouts. The CC's will provide all present capabilities and introduce new functions and capabilities, including the ability to observe and manipulate both radar data (current aircraft position) and flight data (aircraft's intended route to its destination) (FAA-AAP-FIS-5, 1990). About 2,300 Position Consoles (similar to CC's) will be installed at 335 Control

Physical and Functional Elements of Air Traffic Control



Air Traffic Control Tower (ATCT)

- Number - 300
- Functions:
  - —Clearance Delivery
  - —Ground Traffic Control
  - —Active Runway and Airport Traffic Within 5 Mile Radius and <3,000' Altitude

Terminal Radar Control (TRACON)

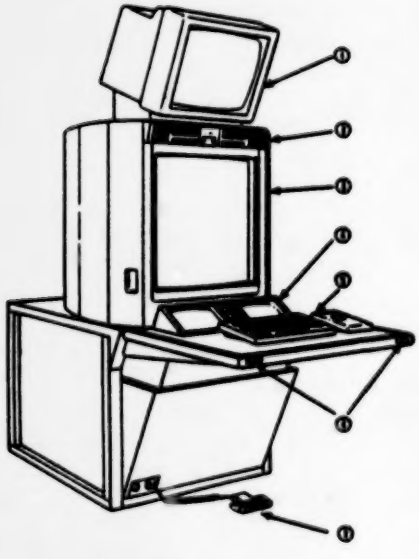
- Number - 186
- Functions:
  - —Radar Separation in Arrival/Departure Flight Phases
  - —Airspace Within 30 Mile Radius and <10,000' Altitude (Exclusive of ATCT Airspace)

Air Route Traffic Control Center (ARTCC)

- Number - 20
- Functions:
  - —IFR Traffic
  - —Radar Separation in Enroute Flight Phase
  - —Procedural Separation Outside Radar Coverage

FIGURE 1

COMMON CONSOLE
Operational Features



1. Auxiliary Display
2. Power and Communications Controls
3. Main Display Monitor
4. Voice Switching and Control System
5. Keyboard and Trackball
6. Headset Jacks (4)
7. Push-to-talk switch

FIGURE 2

Towers after ISSS implementation.

Two graphic display monitors will be available at each CC:

- Auxiliary Display - a high resolution, multi-color, graphics monitor (10" x 12" landscape format at 100 DPI) used to display maps, charts, manuals, and checklists. The Auxiliary Display will be from 36" to 40" from the air traffic controller, requiring that all data displayed on this monitor be designed for distant viewing.

- Main Display - a high resolution, multi-color, graphics monitor (20" X 20" at 100 DPI) which can display either radar images (including weather) for aircraft tracking or data such as maps, charts, manuals, and checklists.

AAS DATA REQUIREMENTS

The AAS project requires nearly 140 gigabytes of data annually. This includes vector data for Controller Charts, Terminal Procedure Publications (TPP's), and High/Low Planning Charts (57.9 gigabytes) and pixel data for Sectional and U.S. Gulf Coast (Helicopter) Visual Charts (81 gigabytes). The NOS will deliver 0.5 gigabyte of Controller Chart data and 4.2 gigabytes of TPP data in AAS machine compatible vector format each 56 and 28 days respectively (Table 1). Monthly, the NOS will update and revise 1.1 gigabytes of pixel data from the Sectional and U.S. Gulf Coast Charts. This data will be incorporated into the existing 6.8 gigabyte pixel database for these charts and the entire database revised and delivered to the FAA in machine compatible pixel format (Table 2). All data will be reviewed and certified prior to delivery to 20 FAA Air Route Traffic Control Centers (ARTCC's) and the FAA Technical Center, Atlantic City, New Jersey. The data sets will be customized for each ARTCC.

Data delivery schedules will be rigidly enforced--no late deliveries can be tolerated. To ensure the safety of the NAS, digital data must be integrated into the Air Traffic Control System on the issue dates of the paper charts used by pilots and must match exactly the data on the paper charts.

CARTOGRAPHIC CHALLENGES POSED BY THE AAS PROGRAM

The NOS must solve numerous cartographic challenges before providing digital data to the FAA. These challenges are outlined in Table 3 and discussed below:

VECTOR DATA (56 Day Cycle)

Chart Type	Number of Chart Panels	Scale	Total MBytes
SCC*	77 (36" x 36")	1:500K	462
TPP	7400 (5" x 8")	1:500K	4,224
Enroute Planning Chart	(not determined)		unknown
SCC and TPP requirement per 56 day cycle =			4,686
Additional TPP requirement at 28 day update=			4,224
Total SCC and TPP requirement per 56 day cycle =			8,910

Average annual (6.5 cycles) Vector Data requirement = 57.9 Gbytes

* Super Controller Chart--replaces 45 High and Low Controller Charts (40" X 55").

TABLE 1

PIXEL DATA (6 Month Cycle)

Chart Type	Chart Panels (36" X 36")	Scale	MByte Scanned	MByte Revised+
Super Sectional Chart	77*	1:500K	26,862	6,716
U.S. Gulf Coast Chart	1.5**	1:1,000K	234	57
Total Megabyte revised semi-annually =				6,773

Total revised annually = 13.5 Gbytes

* Replaces 37 Sectional Charts (40" X 55").
** Replaces one U.S. Gulf Coast Chart (40" X 55").
\+ Data scanned at 500 DPI and then reduced to 250 DPI for storage in the Super Sectional Chart (SSC) database.

Note: only one-sixth of the SSC database will be revised each month; however, the entire SSC database must be recompiled each month and provided to the FAA for a total of 81 gigabytes processed each year.

TABLE 2

GENERALIZED CARTOGRAPHIC PROBLEM MATRIX
FOR MAJOR AAS PRODUCTS

Problem	Terminal Charts	Controller Charts	Visual Sectional Charts
Reduction	Yes	Yes	Yes
Magnification	No*	No*	No*
Text	Yes**	No	Yes**
Symbols	Yes+	Yes+	Yes**
Screen Format	Yes	No	No
Projection Warping	No	Yes	Yes
Chart overlap	No	Yes	Yes
Color	No	No	Yes
Data Density	No	No	Yes
Update Cycle	Yes@	No	Yes@@

Definitions: Yes - indicates the existence of a problem
No - signifies that no problem is known to exist

* Up to 4X magnification with no problem
** Text is too small for distant viewing.
\+ Symbols must be simplified.
@ 56 day cycle with a 28 day update
@@ Only 4 to 7 of the 37 Sectional Charts are revised and inserted into the superchart database each month.

TABLE 3

Text Size

The most critical cartographic challenge is text size. Arthur Robinson (Robinson, 1978) states that "...3-point type is the smallest, just recognizable type at usual reading distance. Normal vision is, however, a misnomer; it certainly is not average vision. It is safer to generalize that probably 4-point or 5-point type comes closer to the lower limit of visibility for the average person." Usual reading distance is defined as approximately 18 inches for people with normal vision, or about one-half the distance from the Auxiliary Display to the controller. Since NOS charts required to support the AAS contain 5-point to 7-point type, some information will not be visible to the air traffic controller on the Auxiliary Display. The controller will have to magnify the image by a factor of 2 or the size of the smallest type doubled.

Magnification

Magnification of the AAS chart data in the 2X to 4X range will be required for viewing on the Auxiliary Display. However, magnification beyond 4X will cause loss of clarity and an increased emphasis of the relative importance of minor features. In

addition, the viewer incorrectly may attribute a higher degree of accuracy to the magnified data because of its larger scale. Magnification may also create another problem. As controllers magnify portions of the charts, they may require increased feature identification (i.e., more road identification, closely spaced river names, etc.) to orient themselves on the chart.

Reduction

Reduction of AAS chart data will result in undesirable and inescapable changes. Adjacent discrete items will become crowded, clarity will be reduced, and there will be an increase in the visual significance of the general to the detriment of the specific. Modifications in layers of vector data will alleviate some reduction problems, but even a 0.5X reduction will render some type illegible. Reduction of pixel data will be harmful--symbols and text will become unrecognizable at reductions beyond 0.67X.

Symbols

Digital pixel symbols will be exact copies of the paper product symbols from which they are scanned and will be satisfactory at reductions of less than 0.67X. Vector symbols will be retrieved from libraries by software, and may be manipulated. Since AAS parameters require that a data screen be drawn in 4 seconds or less, vector symbols must be designed for efficient display and must closely resemble corresponding paper product symbols. Symbol cells should have few vertices and employ area fills whenever possible. Line strings must be used in lieu of circles and arcs, since AAS protocol prohibits use of arcs in symbol generation (Thornburg, 1988). Simplified symbols will be employed and reductions less than 0.67X will be acceptable.

Display Screen Format

Some text on the 5" x 8" (vertical format) TPP's will not be legible on the Auxiliary Display and must be magnified. However, if magnified enough to be legible, the TPP will not properly fit the 10" x 12" landscape format of the Auxiliary Display (Weissberg, 1993). Therefore, 7400 TPP's must be reformatted.

Chart Overlap and Projection Warping

The format of the existing Controller and Sectional paper charts will be redesigned to eliminate overlap. ACD has developed a super chart concept in which two seamless charts, one for Sectional and one for Controller Charts, cover the continental U.S. Each chart uses the same projection parameters. Overlaps will be eliminated and data mathematically warped to fit the 1:500,000 scale super chart projection. Data will be stored in 36" X 36" panels (Buja, 1993).

Color

Vector data will be displayed in 64 colors identical to those on

the paper products with one exception; high and low airspace data will be differentiated by color to allow use of a single controller chart for both levels. The appearance of the digital Sectional and U.S. Gulf Coast Charts will differ slightly from that of the paper charts since only 64 colors will be used for pixel data. Attempts failed to save additional computer memory by reducing the number of colors to 32. (Buja, 1993).

Density and Processing of Scanned Data

For accurate chart portrayal, visual chart data will be scanned at 500 DPI to provide adequate data for such destructive manipulations as rotation, smoothing, and color reduction. The data will be stored at 250 DPI, provided to the FAA at 125 DPI, and displayed at 100 DPI.

Data Updating

Every 56-day cycle the entire Controller Chart database will be updated and reissued to the FAA. The TPP database and indices will be updated in a more complicated process. Every 56-day cycle all 7,400 TPP's must be reissued when 1,000-1,300 procedures are revised. At mid-cycle, a Change Notice effecting 30-100 procedures must be inserted into the database, requiring revision of the database and indices, and reissue of the entire set of 7400 TPP's.

The Sectional Charts present a difficult updating problem. Since the suite of 37 paper charts is on a 6-month revision cycle, 4 to 7 charts are revised and reissued each month. These charts will be scanned and the resulting pixel data reduced from 500 to 250 DPI, warped and rotated, and their colors reduced. The data will be scissored and edge fit into 36" x 36" panels, and finally, the entire database partitioned, inserted into the proper ARTCC data set at 125 DPI and provided to the FAA.

Staffing to Process Data

The data capture, systems support, maintenance, quality control, and processing of over 80 gigabytes of raster data and nearly 58 gigabytes of vector data annually will require a staff of 28, half for the cartographic effort and the remainder to provide systems, programming, and computer support.

CONCLUSION

The NOS faces many cartographic challenges to supply digital charts in support of the AAS. Data handling will be a staggering task. The capture, manipulation, and formatting of vector and pixel data for the FAA will involve processing several gigabytes of data each month. Cartographic generalization and text/symbol depiction will present the greatest cartographic challenges in the AAS project. The NOS must redesign present products to meet these challenges and will work with the FAA to train the air traffic controllers about

the inherent limitations of the cartographic deliverables for the AAS.

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Item 5 (e) of the provisional agenda*

NEW TRENDS IN TECHNOLOGY, AND THEIR APPLICATIONS: HYDROGRAPHY

The Coast and Geodetic Survey's nautical chart rescheming plan

Paper submitted by the United States of America**

* E/CONF.87/1.

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INTRODUCTION

The origins of the Coast and Geodetic Survey (C&GS), a component of the National Ocean Service, National Oceanic and Atmospheric Administration (NOAA), dates to an 1807 Congressional resolution authorizing the President to "...cause a survey to be taken of the coast of the United States, and of the outlying islands and shoals...". After many delays, Ferdinand Hassler, the first superintendent of the Coast Survey (as it was known then) produced the Survey's first nautical chart in 1839, depicting Newark Bay.

Since that time many of the existing C&GS nautical charts, which now number nearly one thousand, were originally planned and produced on an individual, single purpose basis without overall consideration of adjacent coverage or a coordinated area plan. This resulted in the current use of more than two dozen different scales, four different projections, and a variety of paper sizes. In some areas of the U.S., notably Alaska, chart coverage is of a scale too small to adequately serve the requirements of expanding shipping, fishing, and military interests.

MCB has identified three C&GS nautical charting parameters for improvement:

1. Standardize the scales of charts in accordance with international specifications.

Standardizing scales will improve mariner's transitions between adjoining C&GS charts, improve transitions to charts of the Defense Mapping Agency Hydrographic/Topographic Center and Canada, and eliminate odd scales such as 1:210,668 (C&GS Chart 18680).

A coastal charting series of 1:100,000-scale and 1:250,000-scale has been designed for the entire U.S. This new coastal series will facilitate route planning and resource management along the U.S. coasts, and is similar in idea to the standardized topographic series of U.S. maps produced by the U.S. Geological Survey.

2. Standardize chart paper sizes, using the international standards of A0 or derivative sizes.

The International Hydrographic Organization (IHO), of which the U.S. is a member, actively promotes the uniformity and compatibility of hydrographic documents, and the free exchange of

hydrographic chart reproduction materials between member countries. Some countries are not equipped to handle the larger chart sizes currently produced by C&GS. The IHO has recommended the use of A0 paper size as the standard for nautical charts. Standardization of paper sizes will facilitate the exchange of chart reproduction materials.

3. Standardize chart projections.

NOS currently uses four projections for nautical charts:

- Lambert Conformal Conic
- Mercator
- Polyconic
- Universal Transverse Mercator

IHO standards require 1:50,000 and smaller scale charts to be constructed with a Mercator projection. A number of C&GS charts, primarily in the Great Lakes, do not meet this requirement. By reducing the number of projections in use, chart construction techniques will become more unified and easier to manage.

What goals will be accomplished by modernizing C&GS nautical charts?

- The reduction in the number of total charts.

This could be accomplished by standardizing scales (i.e. changing the current 1:40,000 and 1:80,000-scales to 1:50,000 and 1:100,000-scales). However, any reduction in the number of charts by changing scales may be offset by the additional charts required in the new 100,000 and 250,000-scale coastal series.

- The incorporation of requests for changes to the nautical charts by mariners in the private and government sectors.

MCB has kept records of chart user's comments, requests, and complaints about C&GS nautical charts since the 1970s. A weighting algorithm was developed in the 1980s to rank requests and assign resources to new or revised chart construction. Currently, there are over one thousand requests for changes or new charts on file. Limited yearly resources allow for work by MCB on only a fraction of the requests.

During the modernization process, the chart request file will be accessed, and new charting schemes will be developed to accommodate as many requests as possible.

- International standardization.

Meeting IHO standards will ensure that C&GS nautical charts continue to be accepted and used by the international maritime community. Transitions between international and C&GS charts will be easier.

- Cartographic simplification.

Cost savings in compilation may be realized by reducing the number of scales and projections. Charts will be more uniform in appearance and size, and transitions between adjoining charts will be simpler.

RESCHEMING METHODOLOGY

A new PC-based program, called RESCHEME, has been developed within the Nautical Chart Division to assist in designing new and reconstructed chart layouts. RESCHEME is essentially a DBASE III sub-routine, and draws upon the formats of the older MCB CHAPP FILE. The CHAPP FILE (Chart History and Plotting Parameters) is a DBASE data file that contains complete plotting and construction parameters of every C&GS nautical chart. The file contains information such as the title, scale, projection, central latitude and longitude, and geographic positions of all chart corners. RESCHEME creates a CHAPP-like data file format. The program user must input the following information:

- For A0-sized charts; scale, central latitude and longitude, orientation (the orientation of the long axis of the chart; either north-south or east-west). The geographic positions of the corners of the new chart are then calculated and stored.

- For other sizes or insets; scale, latitude and longitude of each corner.

The program user can access the RESCHEME file through DBASE III to enter titles, chart numbers, change projections (the default projection is the Mercator Projection), and manipulate any of the individual records as necessary.

In practice, the chart planner rescheming a particular area uses an existing small-scale paper chart to begin the layout. Templates are made out of mylar or paper, at the correct scale and paper size, and a rough layout is penciled onto the chart. The planner identifies and records the geographic center of each rectangle (or the corners, for odd-sized charts or insets) and the orientation of the long axis. The planner enters this information into program RESCHEME, choosing either the A0 paper option or the inset/other size option.

To view the calculated results of the RESCHEME file, the chart planner must access a second program also developed within the Nautical Chart Division, called FPLOT. FPLOT is a PC-based program, and has the capability of plotting the neatline of the new chart(s), the projection grid, title, and chart number, on the computer monitor. The chart planner can quickly check adjoining chart overlaps and, by accessing the optional shoreline plotting routine, check that bays, harbors, and waterways are fully covered within the appropriate neatlines. FPLOT can also superimpose point information and draw a number of different mapping symbols by accessing optional geographic DATABASE files.

FPLOT utilizes a CALCOMP 1026 drum plotter or MCB's KONGSBERG flat bed plotter for full-scale plots on mylar or paper. Modifications to FPLOT are currently under development to allow reduced plotting to Canon and Hewlett-Packard laser printers.

FPLOT draws correctly-sized neatlines of the new charts onto a mylar base chart. The chart planner can then overlay the mylar onto the paper chart, checking that the new chart neatlines include relative navigational aids and landmarks.

If shifts are necessary to a particular neatline, the chart planner can scale a new center latitude and longitude (or corner positions), change the limits through program RESCHEME, and obtain new plots.

FPLOT does not allow on-screen text modification or changes. However, FPLOT generates a .DXB file that can be imported into AUTOCAD. Recent experiments have successfully added text, shading, and colors to the plots, enhancing the graphic representations.

Benefits of the RESCHEME and FPLOT programs are:

- New charts or changes to the limits of existing charts can be quickly developed and modified in the PC environment.

- New chart parameters are stored in DBASE file format, providing storage for future manipulation or changes. Once a scheme has been approved for production, files can be accessed to provide geographic positions of corners and other chart specifications for the MCB cartographic teams.

- Atlases or presentation plots can be quickly made for review by C&GS personnel or other government agencies or interested parties.

FUTURE DEVELOPMENTS

In the future, MCB anticipates using scanned nautical chart imagery as a backdrop to newly developed schemes. The outlines of new charts, generated by program RESCHEME, will be displayed on the monitor in accurate geographic positions against the chart backdrop, thus eliminating or reducing the need for rough drafts on paper. Incorporating scanned imagery with proposed chart schemes provides an excellent stage for pre-planning tasks and allows a PC environment for all planning work to be performed.

RESCHEMING STATUS

A new 1:100,000 and 1:250,000-scale draft scheme of charts has been developed for all of the U.S. coastline except the Great Lakes. Much of the Gulf and east coast areas have larger-scale rescheming coverage completed in draft form on paper charts, but have yet to be entered into DBASE files. Rescheming of other areas of the U.S. continues on a part-time basis. Completion of the rescheming effort is estimated to take 1 or more years.

CONCLUSION

MCB recognizes that improvements are necessary to the C&GS suite of nautical charts to continue to provide high quality charting products and meet the changing needs of government and

private maritime interests. A reduction in the number of chart scales and projections and the use of A0-size paper will help C&GS meet international charting standards. An active chart rescheming program is underway by MCB. When completed, the plan will provide a basis for improving area coverage, improve overlaps and transitions between charts, and will become a guide to new chart layouts in the future. To aid in the rescheming process the Nautical Chart Division has developed PC-based software and plotting routines that has reduced chart planning time. In the future, MCB will utilize scanned C&GS nautical charts to reduce or eliminate the need for planning new charts on paper copies.

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NEW TRENDS IN TECHNOLOGY, AND THEIR APPLICATIONS: GEODESY

Precise satellite survey results in revised position for the Northern Mariana Islands

Paper submitted by the United States of America**

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** Prepared by Lewis A. Lapine, Chief, National Geodetic Survey Division, National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, Maryland.

INTRODUCTION

In 1993 the Photogrammetry Branch of the National Oceanic and Atmospheric Administration's (NOAA's) Coast and Geodetic Survey (C&GS) completed a large-scale Global Positioning System (GPS) survey of approximately 20 islands in the central and western Pacific Ocean. This survey established a very accurate geodetic network throughout the Hawaiian Islands, American Samoa, Republic of the Marshall Islands, Federated States of Micronesia, Northern Marianas, and Republic of Palau, at the same time upgrading the existing survey control networks of these islands. The accuracy of this network will improve GPS-aided air and ship navigation in the Pacific Basin, provide modern shoreline information for nautical charts, redefine two international maritime boundaries, and more precisely position 25 island airports.

The survey covered an area of several hundred thousand square miles and included measured baselines of nearly 4000 miles. The remote nature of many of the islands and the scarcity of the survey control on these islands increased the difficulty of the project. A survey of this magnitude, especially considering the distances involved and the remote location of many of the islands, requires a great deal of careful planning. Logistics were complex--personnel and equipment had to be transported over great distances on fixed time tables to areas with inadequate airline schedules. Adding to the complexity was the occurrence of several natural disasters during the survey.

Actual GPS survey operations were divided into three distinct phases: (1) a survey of the Hawaiian Islands, (2) extending this survey to 13 other Pacific islands and establishing a precise geodetic network based on the World Geodetic System Datum of 1984 (WGS 84) throughout the Pacific Basin, and (3) tying this network to existing surveys, based on local astronomic datums, in the Northern Mariana Islands. The project was sponsored by C&GS, the Federal Aviation Administration, the Defense Mapping Agency (DMA) and the U.S. Department of State. GPS observations supporting the survey were made by NOAA, DMA, the National Aeronautics and Space Administration (NASA), the U.S. Geological Survey (USGS), Stanford University, Lamont Doherty Earth Observatory of Columbia University, and the University NAVSTAR Consortium (UNAVCO).

PROJECT PREPARATION

Work began in January 1993 with preliminary survey and logistics planning to test the feasibility of a project spanning seven time zones, the International Dateline (IDL), and nearly 4,000 miles of the Pacific Ocean. Geodetic databases of the National Geodetic Survey (NGS), U.S. Geological Survey (USGS), and DMA were researched exhaustively to identify existing survey control. An

important consideration of this investigation was to locate existing survey control data to allow correlation of earlier astronomically-based local surveys to the new GPS survey (and WGS 84), thereby ensuring that existing mapping data could be used to prepare new charts. This was difficult since some of the islands had not been surveyed since 1936.

Government and University geodesists were consulted to develop optimum techniques to establish geodetic control, make GPS observations, and process those observations precisely enough to determine accurate coordinates for baselines expected to exceed 6,000,000 meters (nearly 4000 miles) in length. While these technical issues were resolved, logistic arrangements were coordinated among four government agencies, three foreign governments, and two U.S. protectorates.

Developing a GPS observation schedule was a joint effort of logistics and survey control working groups. With survey crews working thousands of miles apart, on both sides of the IDL, observation schedules had to be carefully coordinated by time and date and for visibility of common satellites. Complicating the undertaking were inconvenient airline schedules. Commercial flights between the remote islands are on a three-day schedule (including crossing of the IDL). Flights are west-bound on one day and east-bound on the next. Shipment of equipment, supplies, camping gear, and emergency stores had to be carefully planned to correlate with transportation schedules, taking into account the custom's regulations of several different countries.

THE SURVEY

The operational phase of the survey began in late July 1993 when 4,500 pounds of equipment were shipped from Norfolk, Virginia; Washington, D.C.; and Seattle, Washington, to Honolulu, Hawaii, the logistical center for the project. In Honolulu two persons provided around-the-clock project coordination. They were responsible for keeping the survey on schedule by locating and shipping replacement equipment, ensuring that the project personnel were in place at the designated times, and coordinating any required changes. Their work was complicated by the remote locations of the observing sites, the three-day flight schedule to the remote sites, the requirement for simultaneous satellite observations over five time zones (including the IDL), lost equipment, flight delays, and missed connections. On some of the islands a problem with a plane or airline crew might delay a scheduled flight until the problem was resolved--no replacement planes or crews were available.

None of these problems compared to those created by nature. During reconnaissance of Guam, only a week before survey crews were to

make GPS observations and to transit the Guam Airport on connecting flights to other islands, a magnitude 8.2 earthquake shook the island. Typhoons and volcanoes were active in the survey area and one observer had to be evacuated as a typhoon approached the island of Hawaii. Even with these obstacles, all phases of the survey, including additional requirements added during the course of the survey, were completed with great success.

Due to the distances involved, baselines between major control stations (one station per island) were observed for 8 hours a day for 6 continuous days in the Hawaiian Islands and for 8 continuous days on the remaining islands. Existing horizontal control networks and tidal bench marks were connected to the GPS network by baselines observed over single or double 8-hour sessions. Major stations were surveyed to Order-A accuracy specifications (5mm ± $1:1x10^7$), while most connections to existing local control were surveyed to Order-B accuracies (8mm ± $1:1x10^6$). A total of 181 geodetic positions (69 in the Hawaiian Islands) were determined from the GPS observations. Of these, 79 were ties to the existing local networks and 11 were collocated on tidal bench marks.

TECHNICAL CONSIDERATIONS

One of the longest baselines, measured between major stations in American Samoa and Republic of Palau, was 6,223,000 meters (3,868 miles) long or approximately 98% of the Earth's radius. To illustrate the magnitude of this baseline, the ends were separated by 21.7 degrees of latitude and 47.1 degrees of longitude (Figure 1). A total of 3,379 observations were used in the computation of this baseline. Accurate computation of baselines this long requires a precise knowledge of variations in the Earth's rotation and of GPS satellite orbits. As GPS satellites orbit the Earth, the terrestrial coordinate system, upon which geographic coordinates are based, is constantly shifting due to rotational irregularities of the Earth. These variations in the Earth's orientation translate into significant coordinate errors for long baselines. To provide corrections for these variations, Very Long Baseline Interferometry (VLBI) radio telescopes are used to monitor signals from extragalactic radio sources. The arrival times of these signals are sensitive to Earth orientation changes, and are used to determine orientation information at the centimeter-level of accuracy. Precise GPS orbits are made available by NGS from data contributed by the world-wide array of GPS receivers operated by the Cooperative International GPS Network (CIGNET). Certain CIGNET GPS receivers, collocated with VLBI telescopes in Japan, Australia, New Zealand, Hawaii, North America, Europe, and Africa, provide information allowing GPS orbits to be rectified for shifts in the Earth's orientation. The combination of Earth orientation information and precise GPS satellite orbits from VLBI and CIGNET GPS receivers provide the information required to determine

accurately this project's extremely long baselines.

RESULTS

The GPS observations from this survey project, along with the precise GPS orbits and orientation information, will be processed by the NGS. Preliminary results indicate that the actual position of several islands in the Northern Marianas will shift by as much as 1.5 nautical miles to the north. One of these islands, Farallon de Pajaros, marks the northern limit of the U.S. maritime boundary. The resulting northerly shift, when confirmed, could increase the exclusive economic zone territorial and fisheries rights of the United States in this region. See Figure 2 for an example of the shift at the island of Sarigan. Final results are expected by early summer of 1995.

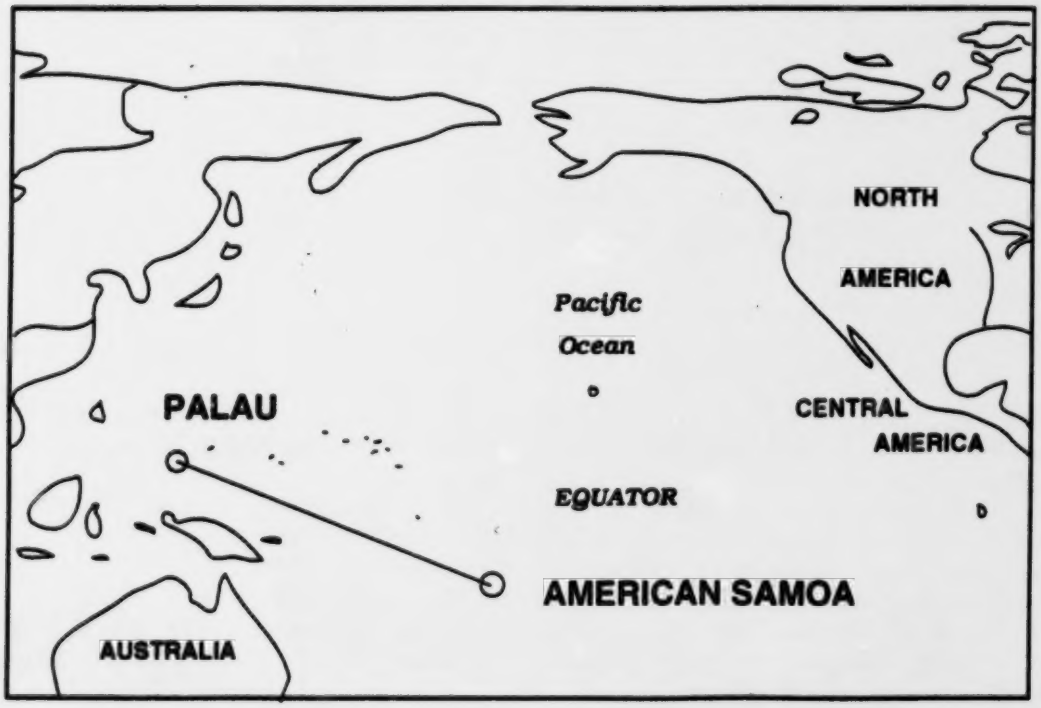

Figure 1
American Samoa to Palau Baseline

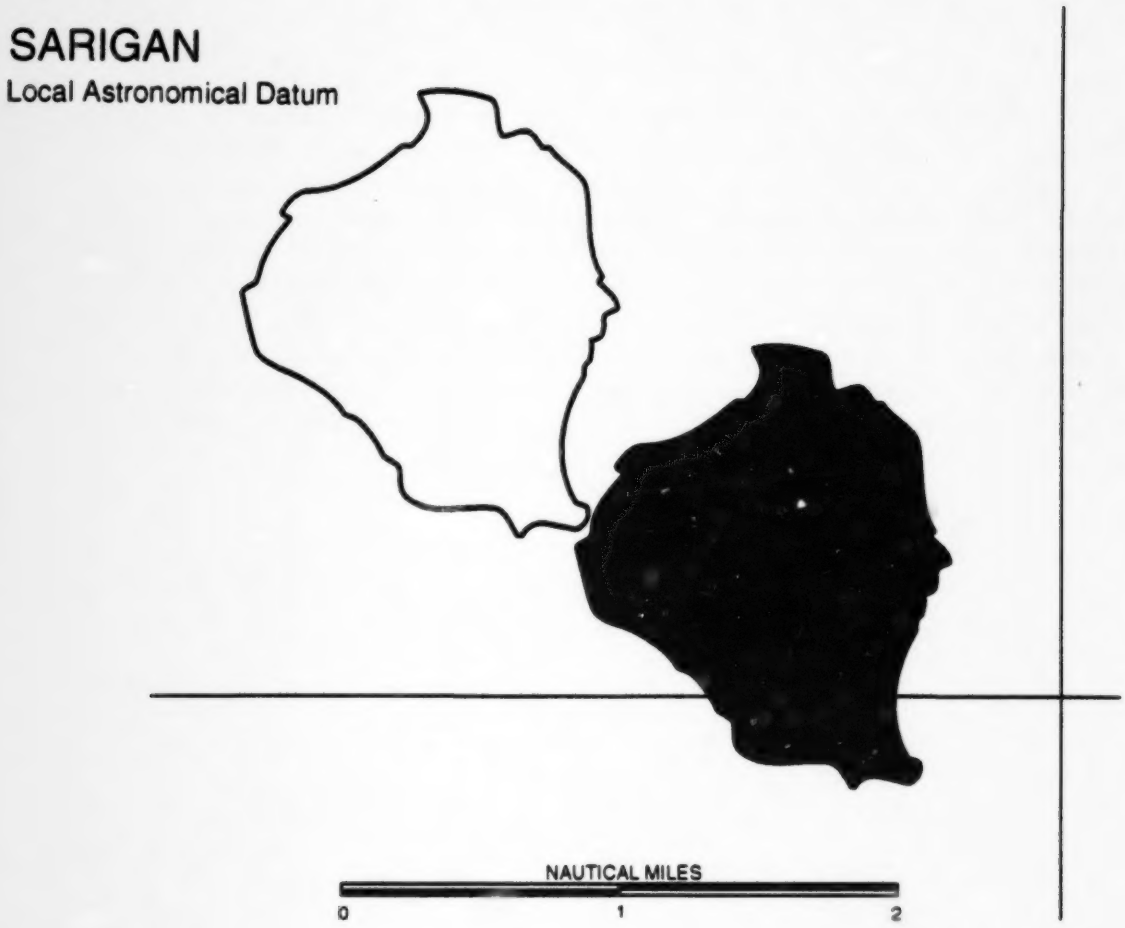

Figure 2
Shift at Island of Sarigan, Northern Mariana Islands

CONCLUSION

Today's technology allows the survey and precise positioning of remote areas of the world in a timely, accurate, and cost-ffective manner not previously possible. Access to this positioning information may result in signficant changes to maps and charts and the territorial and economic rights of nations.

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COUNTRY REPORTS ON THE CURRENT STATUS AND ISSUES OF SURVEYING, CHARTING AND MAPPING AT THE NATIONAL LEVEL: NEEDS AND REQUIREMENTS VERSUS REALITY IN THE REGION

Cartographic activities in New Zealand, 1991-1994

Paper submitted by New Zealand**

* E/CONF.87/1.

** Prepared by the Department of Survey and Land Information, Wellington, New Zealand.

INTRODUCTION

This report describes the progress and development of cartography in New Zealand during the period 1991-1994.

PART 1: CARTOGRAPHIC ACTIVITIES OF THE NEW ZEALAND DEPARTMENT OF SURVEY AND LAND INFORMATION

The Department of Survey and Land Information (DOSLI) was formed in 1987 when the Department of Lands and Survey was disestablished. This occurred as part of a widespread government restructuring programme designed primarily to separate statutory and regulatory functions from potential and existing revenue earning operations. Central government departments involved in the management of natural resources were also integrated through the restructuring programme to consolidate environmental management, policy development and monitoring. These reforms effectively removed conflicts of interest, allowed operational departments to resemble some aspects of private companies, and introduced a requirement to function according to cost recovery or user pays principles. Several State-Owned Enterprises were created, some of which were subsequently sold in the government's State Asset Sales programme, while essential service delivery agencies remained within the state sector.

The new department is the principal government civil and military agency for surveys, mapping and land information. The current state sector environment demands the provision of quality products and services by the department. Consequently, DOSLI has focussed on anticipating and responding to government, local authority and private clients needs, technological developments, and the changing requirements of New Zealand society.

These functions provide the basis for:

- secure land tenure and property rights, and the use and management of land related resources;

- support for the management and monitoring of the environment, communications, security, social, economic, commercial, administrative and government systems in New Zealand and extended as appropriate to the South Pacific and Antarctic regions; and

- assistance in the implementation of the government's policies on indigenous peoples land rights issues as guaranteed by the Treaty of Waitangi, the devolution of service delivery functions to Iwi Authorities, and the transfer of land assets.

There is a responsibility to maintain several major national land record systems that are central to the maintenance of secure land tenure, security and safety, and for general national and public benefit from the carefully planned and sustained use of land resources.

These systems include the:

- Survey control and cadastral system;
- Cadastral survey records and mapping;
- Topographic mapping.

The department is also required to administer or dispose of Crown land not allocated to a government department or State-Owned Enterprise, and provide policy advice to the government on land related issues.

Mention was made in the last report of the mapping activities of the Department of Scientific and Industrial Research. That department ceased to exist in 1992 and its mapping functions were taken up by DOSLI.

THE LAND SURVEY SYSTEM

New Zealand enjoys the benefits of an integrated survey system that was introduced in 1876. This is achieved by:

- Relating every survey to one control system which provides the positional framework for all measurements.
- Standardising procedures, accuracies and records.
- Providing a single source of administration through DOSLI and servicing of the survey industry by a professional body.

Cadastral surveys are defined and governed by the Survey Regulations which are regularly reviewed to meet the changing needs of the land survey system and new technology. The two plan system (survey and title) is being maintained and retrieval of data is readily available through a microfilm system. With the ever increasing use of sophisticated technology in computers and measuring equipment, survey methods and standards are constantly under investigation. All new approved survey data is recorded. This forms the basis for the production of cadastral maps. Approximately 20,000 plans are added each year to the land survey records of the department. These surveys are predominantly undertaken by registered surveyors in private practice.

GEODESY

Utilising GPS technology, a major investigation is presently underway to establish the relationship between the nation's existing geodetic datum (as determined in 1949) and the WGS 84 reference system.

Projects are being undertaken to determine accurate measurements of selected geodetic stations on either side of the Australian and Pacific tectonic plates. This work is being carried out in cooperation with international agencies. As further data is accumulated, it is hoped that a more reliable detection of tectonic movement and associated earth deformation will be established.

Second and third order control surveys have continued, particularly in areas where inadequate reliable geodetic control previously existed. This upgraded work is required to provide a more accurate foundation for digital cadastral database development. These surveys have often been undertaken using a combination of conventional and GPS survey equipment.

A differential navigation service has been established to enhance the accuracy performance of users' remote GPS receivers. Three strategically placed base stations provide a ± 2 - 5 metre real time or post-mission accuracy for any location within New Zealand.

A new survey network adjustment package has been developed which accommodates conventional observations and measurements as well as GPS data.

The national geodetic database is being expanded to include urban and rural standard marks as well as geodetic trig stations and benchmarks. This database is being converted to a new operating environment which will significantly enhance its graphics capability and its association with allied cadastral, photogrammetric and topographic databases.

CADASTRAL MAPPING

New Zealand has complete national cadastral map coverage at scales ranging from 1:1000 to 1:50,000. These total approximately 18,000 maps which are hardcopy, manually drawn and maintained. They are updated daily on approval of new subdivisional plans or on advice of changes to the textual data.

The department has also built a Digital Cadastral Database (DCDB) comprising data on land parcels throughout New Zealand with respect to their geographic location, shape, area and legal description. The database also has a layer defining statistical meshblocks, the smallest geographical collection unit for census and socio-economic data.

By the end of 1995 the DCDB will supersede the manual record maps as on-line enquiry systems are incrementally introduced throughout the country.

The DCDB is being widely used as the spatial base for local and regional government and public utility geographic information systems. It will provide the spatial framework for core land information systems comprising land valuation and land title data. It is being used to provide management and mapping support to administer New Zealand's electoral system, the redistribution of electoral boundaries, and mapping to support the nation's Census of Population and Dwellings.

TOPOGRAPHIC MAPPING

New Zealand has complete national coverage of topographic mapping. The published metric Infomap 260 series (1:50,000 with 20 metre contours) is available over the whole of the North Island and 80% of the South Island. Of the 305 sheets covering New Zealand, 285 have been published. The balance are in various stages of production. Some of the older 1:63,360 imperial mapping is still being used until the 1:50,000 is complete in 1996.

Photogrammetric production of the Infomap 270 series is nearing completion with all but eight sheets in the remote Fiordland area still to be mapped. Fully controlled aerial photography is available over this block. Infomap 270 mapping has been largely captured in graphical form with parts of the more recent areas completed digitally. This series is compiled at 1:25,000 scale, and provides the base material for all derived topographic mapping, with four sheets being reduced and combined to make one of the Infomap 260 1:50,000 series.

With the production of the Infomap 270 series drawing to a close, resources are being directed towards revision of the series. Revision to date has been carried out where necessary by field methods, but a planned programme is now being instituted that will see the 1:50,000 series sheets revised on an average ten year cycle. Methods used will vary with the character of the sheet but will be either by field or photogrammetric methods. Various new technology methods are currently being tested, the most promising of which appears to be the production of a digital orthophoto image at 1:25,000 as an interim step in the process.

Other official mapping series that fully cover New Zealand are the Infomap 262 series of 18 sheets at 1:250,000, and Infomap 242 comprising 4 sheets at 1:500,000. The NZMS 1 imperial specification series at 1:63,360 is being progressively withdrawn as sheets are superseded by the new 1:50,000 series.

DIGITAL TOPOGRAPHIC DATABASE

National coverage of 1:250,000 topographic data is complete, and capture of 1:50,000 data is progressing rapidly, with completion expected by 1996.

Both sets of data have been digitised by scanning the published map line sheets for contours, hydrography and roads. Point features have been added by manual digitising.

All data is fully structured, preserving the fundamental spatial relationships between features, including connectivity, adjacency and containment. Attribute data is added to all features.

The databases have been designed so that a purchaser requiring an update needs only to be supplied with changed or modified features which can then be integrated with the existing data.

PHOTOGRAMMETRIC PROJECTS

Since equipping seven analogue stereoplotters with GeoVision equipment in 1988, the variety of digital mapping work has greatly increased.

To meet a need for seamless topographically structured data for local authorities and utility organisations, 1:500 and 1:1000 scale urban land bases of major cities are being produced.

Vigorous marketing in the important forestry industry sector has increased the amount of mapping for a discerning clientele requiring clean datasets for forest management on GIS and CAD systems. The combination of new photography for feature extraction and historical photography for pre-planted height information, has proved a successful formula for foresters.

Further projects tailored to the needs of land planners involved with the sale of state assets have been carried out, and other work has included line of sight profiles for the telecommunications industry and tower positions and strip maps for power transmission engineers.

AERIAL PHOTOGRAPHY

The department's ability to sequentially cover New Zealand with 1:25,000 aerial photography has been greatly reduced in recent years through financial limitations. However, small key areas have been flown in conjunction with other projects and opportunities have been taken to join in with regional consortiums for the larger areas.

In November 1993 the department co-sponsored an aerial photography mission in Antarctica with the United States Geological Survey. Some 20,000 sq kms of photography was obtained primarily for topographical mapping, monitoring environmentally sensitive areas, and research around Ross Island and the Dry Valleys area. The department maintains a National Photo Library which holds most Crown and some private copyright photography. Some of this is now a valuable historical record. A computerised aerial photo index has been developed and information is currently being entered into this database.

DIGITAL IMAGE PROCESSING

A pilot project is currently underway to asses the viability of establishing a digital spatial database of land cover over New Zealand for resource management purposes, based on classification derived from satellite imagery. Satellite imagery has also been used in combination with cartographic line work in the production of image maps. Resources have been committed to further developing the department's remote sensing capabilities in the forthcoming year.

The quality of hardcopy map output for project mapping jobs, such as forest and highway construction mapping, has improved with the workflow from data capture to output now being totally digital. This fully digital process provides greater flexibility in map sheet design and consistency in map quality.

SCIENCE MAPPING

When the Department of Scientific and Industrial Research (DSIR) was reorganised into Crown Science Research Institutes in 1992, the DSIR's cartographic staff were transferred to the Department of Survey and Land Information, which now produces maps under contract for the Crown Science Research Institutes. These include: oceanographic bathymetry and sediment charts; gravity, magnetism and electrical resistivity maps; geological resources maps; soil and land inventory maps; and a range of charts for the New Zealand Meteorological Service.

Digital scanning and vectorisation services are also provided to enable existing graphic information to be utilised in geographic information systems.

Manual production techniques are rapidly being replaced by computer production and digital plotting methods. Many scientific maps are no longer lithographically printed, with more emphasis being placed on specialised report maps produced in low volumes by high quality inkjet plotter.

AERONAUTICAL CHARTING

Aeronautical Charting is now undertaken on a cost recovery basis. This has led to a review of standards and the development of improved quality assurance procedures.

The range of work carried out for the Royal New Zealand Airforce has reduced now that the client has to pay for chart production. Because of low usage rates, several chart series have been discontinued. Those that have been retained are being redrawn to more closely comply with the Air Standards Coordinating Committee standards.

The other major client is the Airways Corporation of New Zealand Limited. This is a State-Owned Enterprise that has the delegated responsibility, under the regulatory control of the Civil Aviation Authority, to carry out the commercial operation of aviation in New Zealand.

Most chart production and revision is now carried out using computers. The New Zealand National Enroute Navigation Chart, the regional and area charts, and overlays for the visual navigation charts are all produced digitally. There have been considerable savings in time and costs to the client, and products can be revised in a much shorter turnaround time.

The development, control and maintenance of a comprehensive database of aeronautical information has enabled other services to be provided to the industry. A major revision of airspace and the Airways Modernisation Project have utilised this data, together with digital topographic data that was also provided by the department.

TOURIST AND RECREATIONAL MAPPING

Forty five maps are currently produced showing national parks, forest parks, and other major tourist areas. Map scales range from 1:40,000 to 1:250,000 and most maps now have full colour on both sides, with supplementary photographs and descriptive test.

A committee including representatives from the Department of Conservation coordinates the design and collection of data for these maps, to ensure they are of maximum value to users.

HISTORICAL ATLAS

The department is providing all cartographic input to the New Zealand Historical Atlas, including maps, diagrams, graphs, photographs and text. This is being produced entirely within a PC environment, principally using CorelDraw software. The atlas, which is a new publication, is due for publishing in 1996.

PART 2: HYDROGRAPHIC ACTIVITIES OF THE ROYAL NEW ZEALAND NAVY (RNZN)

MONOWAI OPERATIONS

The large scale survey of the Bay of Islands commenced in 1990 and was completed in November 1992. This survey was completed ahead of schedule due in part to the utilisation of GPS for geodetic positioning of shore control. Other surveys carried out by MONOWAI during this time have included safe anchorages for cruise ships on the east coast of the environmentally sensitive sub-Antarctic Auckland Islands and GPS positioning of EEZ base points in the Kermadec Islands, which lie 600nm to the north-east of New Zealand. In 1993 MONOWAI carried out a series of large scale boat surveys in Auckland, Lake Taupo and at Penrhyn Island in the South Pacific Ocean. Shipping routes in the poorly charted Chatham Islands, which lie 360nm to the east of New Zealand, were also completed. In 1994 MONOWAI commenced the resurvey of Fiordland.

INSHORE SURVEY CRAFT (ISC) OPERATIONS

HMNZ Ships TARAPUNGA and TAKAPU supported MONOWAI in the Bay of Islands prior to undertaking surveys of the approaches, bars and harbours of Greymouth, Wanganui and Kaipara on the west coast of New Zealand during 1993. In 1994 the ISC are supporting MONOWAI's survey operations in Fiordland prior to commencing surveys in the Bay of Plenty.

DATA LOGGING AND PROCESSING

The introduction of the Hydrographic Automated Data Logging and Processing System (HADLAPS) in 1991 has been very successful. Within four weeks of acceptance, HADLAPS was being used operationally in the Bay of Islands and the introduction of a co-tidal model in 1993 has further enhanced the system's capability. The RNZN remains satisfied with the overall performance of HADLAPS, with one of the highlights being its user-friendly programs.

The introduction of HADLAPS has reduced the requirement for winter lie-ups which were necessary for data processing and hand drawing final sheets.

EQUIPMENT PROCUREMENT

The RNZN hopes to introduce differential GPS for positional control in the near future. This should reduce manpower requirements and increase productivity on the survey ground. The HF system HIFIX6 is beyond economic repair and the Del Norte microwave Trisponder system is presently the primary Navaid for positional control.

CHARTING AGREEMENTS

The signing of the charting agreement between Tonga and New Zealand in July 1993 is of particular significance. The agreement sees New Zealand supporting Tonga while the Kingdom develops its own hydrographic and cartographic capability. The charts, which are co-produced but printed in New Zealand, have both Tongan and New Zealand crests and numbers. The first chart, produced by a TDS cartographer in New Zealand, was published in October 1993.

CHART PRODUCTION

The modernisation and metrication of the New Zealand chart series has continued; the last British Admiralty chart of New Zealand home waters has been replaced. Two new charts of the Cook Islands have been produced and a third is in preparation.

New Zealand's contribution of eight charts to the medium scale international charting scheme of the SW Pacific has been completed. A large scale international charting scheme of the SW Pacific is now being considered.

A computerised chart production system designated SEACARTIS has been installed. The system is a version of the AUTOCHART system developed by the Royal Australian Navy Hydrographic Service. Based on the Hewlett Packard A990, it has three digitising workstations and two non-digitising workstations. The digitising stations are based on the Mackintosh Quadra 700 and Calcomp 9500 digitisers. All charts will in future be produced on SEACARTIS, enabling a digital chart database to be built up. When staff have more experience of the system, considerable time savings in production are expected.

Software has been purchased to enable data produced by HADLAPS and ocean sounding data currently held on master plotting sheets to be converted into MGD 77 format. This will enable New Zealand to conform to a policy decision of the IHO, that from 1996 its GEBCO ocean sounding data should be in digital format. It will also enable digital data held at the IHO Bathymetric Data Centre to be used more easily in chart production.

Notices to Mariners are now produced to print-ready stage using Microsoft Word on a Compaq 386, producing considerable cost savings. Databases of Vigias, Wrecks, Lights and other chart information are being developed.

Agreement has been reached with several companies for them to digitise/scan charts for use in electronic navigation systems.

Under consideration is the purchase of a GIS stand alone workstation for the investigation and development of electronic charting data suitable for shipborne Electronic Chart Display Information Systems (ECDIS).

Basic cartographic and on-the-job training in chart compilation and production has been provided in New Zealand for a Private of the TDS who produced the first TDS/NZ chart of Tonga while undergoing training. Currently a cartographer from the Fijian Hydrographic Office is receiving on-the-job training in chart compilation and production. Basic training in chart production procedures and techniques has also been given to officers of the Royal Malaysian Navy.

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ENGLISH ONLY

THIRTEENTH UNITED NATIONS REGIONAL
CARTOGRAPHIC CONFERENCE FOR ASIA
AND THE PACIFIC
Beijing, 9-18 May 1994
Item 5 of the provisional agenda*

NEW TRENDS IN TECHNOLOGY AND THEIR APPLICATIONS

Paper submitted by New Zealand**

* E/CONF.87/1.

** Prepared by the Department of Survey and Land Information, Wellington, New Zealand.

INTRODUCTION

The following is a summary of the principal activities in which investigations or trials relating to the application of new technology are currently being undertaken in New Zealand.

GEODESY

A project has commenced to assess New Zealand Geodetic Datum 1949 (NZGD49). This project will determine the present shape of NZGD49, its relationship to World Geodetic System 1984 (WGS84) and its suitability for the future needs of surveying and mapping in New Zealand.

New Zealand is subject to continuous and widespread tectonic earth deformation. A mechanism is required to maintain a geodetic survey system in the presence of such deformation. This is also being investigated.

A high precision geoid model for New Zealand is required to allow efficient use of new technology such as the Global Positioning System (GPS) for heighting.

Future links between geodetic, topographic and cadastral digital databases are being planned.

SURVEYING AND MAPPING

Efficient new kinematic methods of GPS surveying are being investigated.

A network of GPS base stations is being extended to provide infrastructure support for GPS surveying and navigation.

New Zealand will participate in an Australasian GPS Integrity Monitoring network. This will provide immediate or archived information on the status of GPS satellites in the region.

Computer-assisted procedures are being developed and implemented for a variety of cartographic products. High resolution, large format film plots are being produced for offset printing of colour maps using input data from the department's digital spatial databases. Initial digital workflows are being refined to combine both vector data and raster data (orthophotos and satellite images) for high quality printed colour map outputs. Investigations are continuing into the most efficient hardcopy colour proofing options for digital mapping workflows.

PHOTOGRAMMETRY AND REMOTE SENSING

The use of GPS to provide airborne photo control for aerial mapping has been trialed by New Zealand. The technique was applied on an Antarctic mapping project in conjunction with United States Geological Survey. Further studies will be made in New Zealand to reduce photo control requirements and costs.

A pilot project is underway to assess the viability of establishing a national spatial land cover database by classifying Landsat TM satellite imagery.

Image auto-correlation techniques are being tested for the generation of digital terrain models. An assessment is also being made of the ability of new soft photogrammetry equipment to measure control points for aerial photography.

DIGITAL DATABASE, GEOGRAPHIC AND LAND INFORMATION SYSTEMS

A project has commenced to assess the update mechanism for the national topographic database. The primary objectives are to reduce the costs and improve the currency of digital topographic data. The initial focus will be on the viability of using digitally generated orthophotos for pre field-check revision.

Scanning/vectorising procedures are being used to convert the 1:50,000 topographic map series to digital form. A suite of software tools has been developed to provide for more rigorous checking of post-vectorisation editing and contour tagging.

Procedures are being developed for the production of 3-D relief models using data from the digital topographic database. Images of these models are being used in cartographic products such as the Historical Atlas of New Zealand.

Software has been developed to provide direct user graphic access to national vector cadastral data from an Oracle database.

FURTHER INFORMATION

Further information on any of the above items is available on request. Correspondence should be addressed to:

Director General/Surveyor General
Department of Survey and Land Information
CPO Box 170, Wellington
NEW ZEALAND

UNITED NATIONS **E**

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THIRTEENTH UNITED NATIONS REGIONAL CARTOGRAPHIC CONFERENCE FOR ASIA AND THE PACIFIC
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Item 7 of the provisional agenda*

REGIONAL COOPERATION AND TECHNOLOGY TRANSFER

United Nations cartographic technical meeting

Paper submitted by New Zealand**

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* E/CONF.87/1.

** Prepared by the Department of Survey and Land Information, Wellington, New Zealand.

INTRODUCTION

The resolution that a mid-term Regional Technical Meeting should be held was strongly supported by the Twelfth United Nations Regional Cartographic Conference for Asia and The Pacific, held in Bangkok during February 1991.

New Zealand offered to host the meeting subject to obtaining the approval of the New Zealand Government and to receiving financial support from the United Nations.

The New Zealand Government, in response to a detailed proposal submitted by the Director General/Surveyor General of the Department of Survey and Land Information, agreed to contribute US$65 000 towards the cost of hosting and organising the meeting, and a further US$70 000 was sought from the United Nations Development Programme (UNDP) and other sources. Unfortunately, UNDP funds have to date been fully committed to other projects, and it has not been possible to convene the Technical Meeting.

Correspondence with the United Nations on the proposal has resulted in the submission of this paper to the United Nations Regional Cartographic Conference for Asia and the Pacific requesting the Conference to consider holding the Technical Meeting in 1996.

TECHNICAL MEETING THEME

The proposed theme of the Technical Meeting is "Cartography For Sustainable Land Management". It is felt that this focus will enable cartographers to make a major contribution towards the issues facing most countries in the coming decade. Land, water and air are mankind's most valuable resources, and cartographers have new and challenging roles in the recording of these resources and the changes which affect them.

Environmental decisions that have arisen from United Nations conferences and other significant forums provide material for sessions and action programmes at the Meeting. The principal objective will be to assist in identifying how developing cartographic technology can be used to translate broad environmental objectives into applied environmental and land management.

Special attention will be paid to presentations that convey a practical approach to the use of cartographic technology at a level that delegates can usefully apply in their own countries.

NEW ZEALAND'S SUITABILITY FOR THE TECHNICAL MEETING

The New Zealand Government is a world leader in implementing far-sighted legislation which controls the management of land related resources, and is well advanced in the development of policies for sustainable land management. New Zealand surveyors and cartographers are closely involved in planning activity, and planning and land management issues can be included in the programme.

The New Zealand Government is also committed to addressing the concerns of its indigenous people and is implementing policies to redress unfair land acquisition practices of the past. The Department of Survey and Land Information is an important source of information on current and historical land tenure, and it is believed that the systems developed are of major importance to other countries.

New Zealand has a strong cartographic community with a highly developed infrastructure in surveying, mapping and land information. The Department of Survey and Land Information, as the primary civil and military mapping agency, is well able to support and channel the combined industry resources from the government and private sectors towards a successful outcome for the Technical Meeting.

The Department of Survey and Land Information is a leader in the cost effective use of new technologies in digital mapping, photogrammetry, global positioning and geographic information systems and their application in small countries.

Cartographers in New Zealand have close working links with their counterparts in the Pacific and there is a history of official cooperation and assistance.

The department also has considerable experience in organising successful international conferences and meetings. These have included the 1980 United Nations Regional Cartographic Conference for Asia and the Pacific, a major Federation Internationale des Geometres (FIG) meeting in 1988, the 1990 South Pacific Place Names Conference, and active participation in the organisation of the 1991 AURISA conference of the Australasian Urban and Regional Information Systems Association.

Technical Meeting Venue

The Technical Meeting could be held in Wellington, the Capital city of New Zealand and the centre of government and administrative activity. All of the facilities required for such a meeting are easily accessible, and many of the government departments, local authorities, public utilities and other organisations of interest for technical tours are located either within the city or nearby.

PROGRAMME

A draft programme has been prepared and is attached as Appendix A.

Each session will commence with a paper that sums up the history and current state of the subject, setting the scene for the following presentations. Effective session leadership will be provided, and all speakers clearly directed on timing, delivery and the quality of visual aids.

Two parallel programmes are proposed, with Session 1 providing an emphasis on technical cartographic applications while Session 2 will concentrate on management issues pertaining to cartography and sustainable land management.
Delegates will be able to select their own programme from both sessions.

The United Nations is invited to lead sessions in which it has special interest.

Recommendations on alternative sessions to those shown in the draft programme are welcomed.

FINANCE

In addition to US$65 000 to be provided by the New Zealand Government towards the cost of holding the Technical Meeting, a further US$70 000 will be required.

If the Conference supports the proposal, a submission will be made to the United Nations Development Programme for US$50 000, and other sources will be approached with a view to obtaining the remaining US$20 000.

CONCLUSION

Many of the countries within the Asia and Pacific Region would gain substantial benefits through increased awareness of the new technology and ways in which it can be used for a wide range of cartographic and allied applications in support of sustainable land use and management.

The Thirteenth United Nations Regional Cartographic Conference for Asia and the Pacific is therefore urged to strongly support the proposal to convene a Technical Meeting in New Zealand in 1996.

APPENDIX A

UNITED NATIONS REGIONAL CARTOGRAPHIC TECHNICAL MEETING: CARTOGRAPHY FOR SUSTAINABLE LAND MANAGEMENT PROPOSED PROGRAMME OUTLINE

MONDAY

DAY 1	PLENARY SESSION	
8.30 - 9.30	Registration	
9.30 -10.00	Administrative session	
10.00-10.30	Morning tea	
10.30-11.30	Maori welcome	
11.30-12.30	Current state of regional cartographic technology (Reports from each country to be provided in advance. Lead speaker to present a keynote address based on a summary of the country reports).	
12.30-1.30	Lunch	
	CARTOGRAPHIC APPLICATIONS SESSION 1	MANAGEMENT ISSUES SESSION 2
1.30-3.00	Remote sensing and photogrammetry	Global environmental change and its impact on cartography
3.00-3.30	Afternoon tea	Afternoon tea
3.30-4.30	Capture mechanisms for digital cartography	Resource management applications of remote sensing

TUESDAY

DAY 2	CARTOGRAPHIC APPLICATIONS SESSION 1	MANAGEMENT ISSUES SESSION 2
8.30-10.00	Vectorisation in digital cartography	New resource management approaches in NZ and their implications for other countries
10.00.10.30	Morning tea	Morning tea
10.30-12.00	Toponymic education and practice	The role of global positioning systems in assisting planning and land management
12.00-1.00	Lunch	Lunch
1.00-2.30	Cadastral and topographic databases and their management	Incorporating statistical, social and economic data into environmental GIS
2.30-3.00	Afternoon tea	Afternoon tea
3.00-4.30	Maintaining data integrity in spatial databases	Information needs, data analysis and cartography in the development of resource management policy and plans
Evening	Cocktails with the President of the meeting	

WEDNESDAY

DAY 3	CARTOGRAPHIC APPLICATIONS SESSION 1	MANAGEMENT ISSUES SESSION 2
8.30-10.00	Integration of spatial data and transfer standards	Technical tour of DOSLI's survey and mapping facilities
10.00.10.30	Morning tea	Morning tea
10.30-12.00	Technology for recording diverse forms of land ownership	Technical tour of DOSLI's survey and mapping facilities
12.00-1.00	Lunch	Lunch
1.00-2.30	Technical tour of DOSLI's survey and mapping facilities	Technical tour Wellington Regional Council
2.30-3.00	Afternoon tea	Afternoon tea
3.00-4.30	Technical tour of DOSLI's survey and mapping facilities	Technical tour of Crown Research Institute remote sensing facilities

THURSDAY

DAY 4	CARTOGRAPHIC APPLICATIONS SESSION 1	MANAGEMENT ISSUES SESSION 2
8.30-10.00	Spatial data applications for urban resource management	GIS applications for natural resource management and hazard planning
10.00.10.30	Morning tea	Morning tea
10.30-12.00	Spatial data applications for rural resource management	Administration of policies and plans - some case studies
12.00-1.00	Lunch	Lunch
1.00-2.30	Technical tour Wellington Regional Council	Measuring sustainable management. Monitoring policy achievement and environmental performance
2.30-3.00	Afternoon tea	Afternoon tea
3.00-4.30	Technical tour of Crown Research Institute remote sensing facilities	The review and modification of policy as a result of monitoring. The effective use of feedback mechanisms
Evening		Formal dinner

FRIDAY

DAY 5	CARTOGRAPHIC APPLICATIONS SESSION 1	MANAGEMENT ISSUES SESSION 2
8.30-10.00	Cost recovery from survey and mapping activities. Copyright, licences, royalty	Survey and mapping input for resource allocation and management
10.00.10.30	Morning tea	Morning tea
10.30-12.00	International technology transfer - implementation issues	Information sharing through technology transfer - management issues
12.00-1.00	Lunch	Lunch
	PLENARY SESSION	
1.00-2.00	Sustainable land use - a new challenge for cartographers	
2.00-3.00	Closing session	
3.00-3.30	Afternoon tea	

SATURDAY

DAY 6	NON-GOVERNMENT ORGANISATIONS
9.00-10.15	Information needs, availability of information for sustainable resource management. The role of NGO's, government and the professions.
10.15.10.30	Morning tea
10.30-12.00	Cartographic methodologies for sustainable resource management.
12.00-1.00	Lunch
1.00-2.30	The experience of NGO's in planning and resource management policy development, implementation and performance evaluation.
2.30-3.00	Afternoon tea
3.00-4.00	Meeting conclusions - where to from now? Panel discussion on access to information, availability of methodologies for future resource management.